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XXIV.—SOURCES OF INDUSTRIAL ALCOHOL.

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A review of the sources from which alcohol is obtainable was given in *Kew Bull.*, 1912, pp. 113–130. At that time its use in various industries was extending and since then its importance as a commercial article has been very much increased owing to the strong movement in connection with its employment as a fuel for internal combustion engines.

During the War a mixture of alcohol and ether, itself made from alcohol, was used as the promoting solvent in the manufacture of the service propulsive explosive, cordite; alcohol was also one of the raw materials employed in the production of mustard gas. In the interest of these requirements, and in order to economise freight and conserve foodstuffs, the whole of the distilling industry was controlled during that period.

The British Empire is almost entirely dependent on imported petrol, and the production of alcohol as an alternative or supplementary motor fuel has been engaging the attention of the Department of Scientific and Industrial Research, and through it of the Dominions, Colonies and Protectorates.

The following notes are intended to amplify and bring up to date those issued in 1912. As in the previous paper, the sources are grouped under the headings (1) Fruits, (2) Roots, Tuberous-roots and Root-stocks, (3) Grain, (4) Stems, (5) Leaves, (6) Inflorescences, (7) Cellulosic Materials, including Wood or Woody substances, Peat, and Vegetation in general. Notes are added on Motor Fuels containing Alcohol and Denaturants. In cases where subjects have been previously dealt with in the *Kew Bulletin*, the references are quoted within brackets; specific references to books or papers are given within square brackets at the end of each subject, and general references are given in chronological order at the end of the paper.

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(1) Fruits.

Carob or **Locust Bean** (*Ceratonia Siliqua* Linn.). A tree, 15–25 feet high, native of S. Europe and the Mediterranean region. Wild and cultivated in N. Africa; naturalised in certain parts of India, cultivated in the West Indies, etc. Grafted trees come into bearing at about 3 years, begin to bear fairly well after 6 years and in 15 to 20 years are in full production. At first each tree yields approximately 35 lb. of pods, and when mature 150 to 650 lb. The yield of spirit may be from about 18 to 24 litres per 100 kilog. [*K.B.*, Add. Ser. ix. pp. 261–263, *K.B.* 1919, p. 16.]

Fig, Smyrna Fig (*Ficus Carica* Linn.). A deciduous tree about 20 feet high, native of Asia Minor and Syria, cultivated in India, Baluchistan, Afghanistan, Kashmir, S. Europe, N. Africa, America, Persia, and many sub-tropical countries. The fruit is recommended as a source of alcohol. A single tree has been known to produce over 150 kilog. of (dried) figs and on soils of average quality 50 kilog. of (dried) fruits are produced per tree and 4,500 kilog. per hectare. The actual alcohol yield of ripe figs is almost equal to that of plums; 30 to 33 litres of 54° alcohol is given by 100 kilog. of dried figs. One hectare of fig trees produces 800 to 900 litres of 90° alcohol. Either fresh or dried fruit can be used. ["Figs as a raw material for Alcoholic Manufacture," Inter. Rev. Agric. Rome, 1922, p. 1153. *K.B.* Add. Ser. ix. pp. 620–622.]

Prickly Pear (*Opuntia* spp.). Succulent shrubs, 3–6 feet high, natives of the dry regions of tropical America; grown in Texas, California, Arizona and New Mexico. Various species have been introduced into S. Europe, N. and S. Africa, Canary Islands, Madeira, India, and many other hot countries on account of their fruit (*K.B.* 1919, p. 56), and in many instances they have become more or less a pest. In India the prickly pear has over-run immense areas and also in South Africa, Australia, etc., where legislative measures have been taken to keep the plant under control. In Queensland and New South Wales the acreage of "prickly pear lands" is calculated in millions on an increasing scale—many thousands of acres of which are the best grazing and agricultural land of the interior. The estimate of areas infested in 1919 was, for Queensland over 20,000,000 acres, and for New South Wales, over 2,000,000 acres. For profitable distillation the fruits should be conveniently obtainable in quantities of at least 10 tons per acre, capable of producing about 110 gallons of spirit. "Springbok" is the name of a motor spirit obtained from prickly pear fruit in the Orange Free State; it is mixed with certain chemicals the formula of which is not disclosed. *Opuntia stricta* Haw. (*O. inermis* DC.) is one of the commonest "pest pears." [Cellulosic Materials—"Stems of Prickly Pear" (see p. 209). "Report of the Prickly Pear Travelling Commission," T. H. Johnston

and H. Tryon, pp. 1–131 (Govt. Printer, Brisbane, 1914). "Some Uses of the Prickly Pear," Ind. Forester 1917, pp. 47–50. "The Prickly Pear in Australia," W. B. Alexander, Inst. Sci. and Ind., Bull. No. 12 (Melbourne, 1919), pp. 1–48, "As a Source of Alcohol," pp. 22–23. "Prickly Pear in U.S.A.," R. D. Watt, Sci. and Ind., Australia, ii. 1920, pp. 679–681. "Prickly Pear: Possibilties of Its Utilisation" C. F. Juritz, S. Afr. Journ. Ind., 1920, pp. 803–814. "Utilising Prickly Pear and Spineless Cactus," J. Burtt-Davy, S. Afr. Journ. Ind. 1920, pp. 1001–1011.]

Coffee Pulp (*Coffea arabica, C. liberica, C. robusta*) has been experimented with by P. de Moraes (Inter. Rev. Agric. Rome, 1911, p. 1128) who found that 1000 kilog. (2200 lb.) would yield 127 litres of alcohol.

Horse Chestnuts (*Aesculus Hippocastanum* Linn.) in experiments carried out by M. Kayser (Paris) have yielded 27–28 litres of alcohol from 100 kilog. of dried fruits (Inter. Rev. Agric. Rome, 1918, p. 111).

Acorns of Common Oak (*Quercus pedunculata* Ehrh.), Durmast Oak (*Quercus sessiliflora* Salisb.) and Evergreen Oak (*Quercus Ilex* Linn.) have been found by M. Kayser (l.c. 112) to yield 8·58 to 20·16 litres of alcohol from 100 kilog. of dry acorns (whole), and from the kernels alone 28–31 litres.

Persian Lilac (*Melia Azedarach* Linn.). An ornamental tree widely cultivated in tropical Africa, India and many other tropical and sub-tropical countries. M. Rigotard (Inter. Rev. Agric. Rome, 1919, p. 993) has suggested the use of fruits, which he found to contain in the outside pulp 29·88 per cent. of sugary matter, from which it was estimated that the possible yield in alcohol at 100° G.L. was nearly 10 per cent. of the air-dried fruit. [*K.B.* Add. Ser. ix. pp. 144–146.]

(2) Roots, Tuberous Roots and Root-stocks.

Beetroot (*Beta vulgaris* Linn. var.), including the Beetroot, Sugar Beetroot, Mangold, Mangel or Mangold-Wurzel. It has been stated (*K.B.* 1912, p. 118) that the Sugar Beetroot is the most important source of industrial alcohol in France, and some figures show yield and production of spirit which compare favourably with those ruling at the present time. It was indicated by Vilmorin that 16–18 per cent. of the gross weight of the root was as much sugar as could be expected consistent with the proper vegetative development of the root (*K.B.* 1897, p. 317; 1919, p. 67). In 1920–23 some experiments were made in the cultivation of Sugar Mangolds as a source of alcohol at the Royal Naval Cordite Factory, Wareham, and at several Stations under the direction of the Ministry of Agriculture. Seeds were obtained from Messrs Vilmorin-Andrieux and Co. of Paris, the variety "Betterave de distillerie à colet vert" proving the best. It yielded about 16–23 tons of roots per acre,

calculated to yield 10 gallons of 95 per cent. alcohol per ton (Fuel Res. Bd. 2nd memo. 1921, 3rd memo. 1925). The distillation of Mangolds was attempted in England at Cirencester about 1860, and proved a complete failure, owing, it was stated, to the low percentage of sugar in the roots (rarely more than 4–5 per cent.), and to distilling operations. Samples of so-called "German Rum" manufactured from beet-juice have been pronounced by experts who have had considerable experience in the West Indian (Sugar Cane) production as "not even equal to the lower grades of Jamaica or Demerara Rum." As a source of sugar, beetroot is grown on a large scale in Europe and the United States, and also at home (*K.B.* 1919, pp. 67–68). A factory erected on the Kelham Estate, Norfolk, covering 41½ acres, owned by Home Grown Sugar, Ltd., has a capacity for dealing with 60,000 tons of beet during the season, or about 600 tons per day of 24 hours, the total production being estimated at 8000 tons of sugar, 3000 tons of dried pulp, and 1800 tons of molasses from which alcohol might be distilled. [*K.B.* Add. Series ix. pp. 546–549. "The Beet Sugar Industry of the United States in 1920," C. O. Townsend, Bull. No. 995, 1922, U.S. Dept. Agric. "Betterave et Sucrerie de Betterave," E. Gaillard (J. B. Ballière et Fils, Paris, 1923).]

Bitter Cassava (*Manihot utilissima* Pohl.) and **Sweet Cassava** (*Manihot palmata* var. *Aipi* Muell. Arg.). Shrubs 3–6–10 feet high, but differing according to the variety, of which there are many. Natives of Brazil and cultivated more or less for food throughout tropical Asia, America and Africa; commonly known as "Mandiocca," "Tapioca," "Brazilian Arrowroot." A convenient and very successful way of shipping the root of Cassava is to prepare it by cutting into small round pieces and drying in the sun, and it is stated that in Brazil the best and most important feature of the Manioc industry is its exportation in dried pieces, which the European markets insist on for the manufacture of alcohol (*K.B.* Add. Ser. ix. p. 603). Cassava is used in the United Kingdom for the manufacture of spirits; the starch contained in the dried roots averages 67 per cent., on which the yield of alcohol is 59·8 litres per cent. (l.c. p. 604). The yield of alcohol is recorded as being 35 gallons (of 95 per cent.) per ton (2nd memo. Fuel Research Bd., 1921, p. 2). In the fresh state, high grade roots contain about 30 per cent. of starch, and 5 per cent. of sugar. Experiments in yield of alcohol recently conducted by A. E. Collens (Govt. Laboratory, Trinidad) showed that freshly dug roots, pulped and boiled, and treated with malt, yielded 18·9 galls. per ton on material as used, or 75·6 galls. per ton on dried material; roots purchased in the open market, grated and boiled, and treated with taka-diastase, yielded 32·6 gallons per ton on material as used, or 81·5 gallons per ton on dried material (Bull. Imp. Inst., 1915, p. 604).

The yield of roots varies for different countries, according

to period (18 to 24 months) when the roots are dug up, from approximately 6 to 10 tons per acre (*K.B.* Add. Ser. ix. p. 602.)

It is possible that this root in any of our Tropical Colonies would be a reliable source of material for distillation on the spot or for export in a dried condition to Europe for distillation; but success would depend entirely on local conditions. The subject of production of alcohol from Cassava was being given special consideration on the Gold Coast in 1921–1924 (Ann. Rep. Dept. Agric. Gold Coast 1921, p. 12; 1924, p. 11) and, as shewing the possibilities of production of the root, negotiations were also undertaken in 1921 for the disposal of 100 tons of dried Cassava roots in the United Kingdom (Col. Rep. Ann. No. 1154, Gold Coast, 1921 (pub. 1923), p. 55). [*K.B.* Add. Series ix. pp. 600–606.]

Potato (*Solanum tuberosum* Linn. var.). In the paper of 1912 in regard to the potato it was stated (p. 118) "that in the present agricultural conditions of this country it would not be possible to found a profitable industry." This would cover Great Britain and Ireland and the conditions at the present time do not appear to have materially changed in favour of the production of spirit on a commercial scale. The same may be said of other areas in the Dominions where the potato can be grown. For instance in South Africa it is recorded that "Potatoes are a possible source of commercial alcohol; but only damaged ones are economically available. Sound potatoes fetch more as a food than can be paid for them as a raw material for fuel." The Potato Alcohol situation has changed in Germany since the records of the previous paper, but it appears to be still of first importance in comparison with other countries, and it is reported that "Recovery in the Alcohol Industry necessarily waits upon a restoration of the potato production to something like pre-war standards, as the Government limits the price which alcohol manufacturers may offer for potatoes in the interests of conserving the potato crop for human and animal consumption." Meantime the demand in alcohol is being met partially by the importation of Corn (Indian Corn—*Zea Mays*, being no doubt meant), and "since October, 1919, the alcohol industry has been a State monopoly, the production and distribution being carefully supervised and the selling price fixed by the State". In 1913, when our home production of potatoes was more than 7·5 million tons from 1,173,418 acres, Germany could presumably supply her own wants for food and also afford to send us 115,452 tons (*K.B.* 1919, p. 63) and as well to distil 2·7 million tons of tubers (these figures for 1913–1914 are assumed to refer to the crop of 1913), producing 3,844,000 hectolitres of alcohol. The acreage for 1913 is not available at the moment, but it will be near enough to say that it would no doubt exceed 8,000,000 acres as in 1909 and 1910 (*K.B.* 1912, p. 117). In 1921–1922 the production of alcohol in Germany was estimated at 1,100,000 hectolitres (including grain alcohol from imported

Corn, *Zea Mays*, see note above). In October, 1921, the price of alcohol from grain and potatoes was fixed at 1,000 marks per hectolitre ; by August 15th, 1922, the price of grain alcohol had been gradually raised to 5000 marks, while that from potatoes remained unaltered. Other figures might be quoted ; but those given are sufficient to show that in comparison with the area available in Germany, there is in Great Britain only a small area available for such cultivation out of a total of some 30,000,000 acres of agricultural land.

Florida Arrowroot (*Zamia floridana* DC.), known in Florida as " Coontie," is found growing in the Pine-lands (*Pinus caribaea* Morelet) which cover vast areas of S. Florida, where this *Zamia* (next to the " Saw Palmetto ") is said to be the most remarkable plant in the undergrowth. The starch or arrowroot as a source of food in Florida is a well-known production; samples of the starch and specimens of the plant have been in the Museum at Kew since 1887. The " Zamia Palm " is reported to yield 13 gallons of 95 per cent. alcohol per ton (2nd memo. Fuel Res. Board, 1921, p. 2), but there appears to be no information available as to cultivation on a commercial scale. It does not seem to be a plant that could be recommended for cultivation. In the region where the plant is collected for manufacturing purposes—restricted to a limited area near Miami, Florida—it is stated that " the same region may be profitably worked over once in five years." [" Seminole Bread, the ' Conti ', a History of the Genus Zamia in Florida," J. K. Small, Journ. New York Bot. Gard., 1921, pp. 121–137. " A report on the Zamia Starch Situation," J. F. Clevenger, Amer. Journ. Pharm., Feb., 1922, pp. 98–103. " Florida Arrowroot from *Zamia floridana* ", T. E. Wallis, Pharm. Journ. March 17, 1923, pp. 235–238.]

Macrozamia spiralis Miq., the " Burrawong " of Australia, also called " Zamia Palm " or " Native Pine Apple ", is found in New South Wales and Queensland, chiefly in poor land of little value for agricultural purposes, and is reported to cover many thousands of acres ; it is also found in damp low-lying soils and on stony hill-sides. In a collection of bulbs (root-stocks) collected by the Forestry Commissioners of New South Wales from different localities in the State, the largest weighed 388 lbs., the age being computed at 120 years, and the smallest weighed 18 lbs., age 65 years. The results of experiments go to show that the yield of alcohol from both inner and outer cores is about 14 gallons per ton, and it was estimated that if the butts could be delivered at 12s. per ton the cost of the raw material (alcohol) would be about 10d. per gallon. This plant could only be of value while the wild resources lasted, and considering the slow growth as evidenced by the age of the plants experimented with, cultivation would be out of the question. [" *Macrozamia spiralis* as a Source of Industrial Alcohol,"

G. Harker, Sci. & Ind., Australia, 1919, pp. 470–475. "Power Alcohol from Macrozamia," Sci. & Ind., Australia, 1920, p. 70. "Utility of Zamia Palm for Stock Food," Agric. Gaz. N.S. Wales, 1922, p. 169.]

Artichoke (*Helianthus tuberosus* Linn.). In the course of some experiments at the Royal Naval Cordite Factory, Wareham, it was found that very good yields of alcohol could be obtained from the tubers, and cultivation was recommended to supply a limited quantity of alcohol for special purposes in combination with the production of cellulose (see Cellulosic Materials). It was realised, however, that the cost of cultivation on a field scale and the restricted areas available would prevent any large quantities being produced (Rep. Comm. for Sci. and Ind. Res., 1920–21, p. 43). In the experiment the yield per acre of roots was from 13–15 tons grown in garden soil, and about 6 tons in heathland, a ton of roots being estimated to yield 19 gallons (of 95 per cent.) of alcohol (2nd memo. Fuel Res. Bd., 1921, pp. 2, 4, 5). In the previous paper (*K.B.*, 1912, p. 120) a ton of Artichoke roots was stated to yield 25 gallons of alcohol. ["Jerusalem Artichokes as a Raw Material", 3rd memo, Fuel Res. Bd. 1925, pp. 7–21; 32–37.]

Sweet Potato (*Ipomoea Batatas* Linn.). An extension of the intensive cultivation is advised in S. Africa where there are large tracts of suitable land, a possible yield being 6 to 7 tons or more per acre, affording 35 gallons of 95 per cent. alcohol per ton (2nd memo. Fuel Res. Bd. 1921, pp. 2, 8). A liquid Motor Fuel named "Acetol" obtained from Sweet Potatoes has been patented in S. Africa (Juritz, S. Afr. Journ. Ind., Oct., 1920, pp. 889–894). In Queensland also the Sweet Potato is regarded as a promising source of alcohol (Inter. Sugar Journ., Feb., 1922, p. 102). [*K.B.* 1912, p. 119; Add. Ser. ix. pp. 475–479.]

Eddoes (*Colocasia Antiquorum* Schott) and **Tannias** (*Xanthosoma sagittifolium* Schott) as starchy materials have, like the **Yams,** *Dioscorea* spp. (*K.B.* 1912, p. 120), come under consideration for distillation, but being for the greater part native products, it is open to question whether there would be any produce to spare after the food requirements have been met, or whether it would pay to cultivate them on an increased scale to allow for the production of alcohol. In comparison with Potatoes and Sweet Potatoes, though the yield (3–5 tons approx.) may be about the same or somewhat less, the period of growth, which is upwards of 12 months, is longer. [*K.B.* Add. Ser. ix. "Eddoes" and "Tannias" pp. 755–757, and "Yams" pp. 689–698.]

(3) Grain.

Maize (*Zea Mays* Linn.). An annual plant 4–6 feet high, cultivated in many varieties throughout the Tropics and Sub-

tropics. The yield of alcohol is given at 83 gallons (95 per cent.) per ton, and as stated in the previous paper (*K.B.* 1912, p. 121), maize is the chief source of industrial alcohol in the United States. This source of alcohol fuel is considered the most promising in S. Africa, where it is produced in large quantities in districts where the cost of petrol is highest; a 200 lb. bag of "mealies" produces 8 gallons of 95 per cent. alcohol—approximately the same as above at 11 bags per ton—and upwards of 100 lbs. of an excellent food for animals. "Penrol" is a motor spirit in South Africa, described as consisting of alcohol from mealies and dissolved acetylene (Inter. Sugar Journ., Aug., 1921, p. 471). Maize growing should be capable of great development in our Tropical Colonies, both for home and local production of alcohol. Considering the immense trade in the grain existing between the Argentine, United States, Roumania, Canada, British India, West Africa, South Africa, etc., and the United Kingdom—our imports being more than 2,000,000 tons a year (*K.B.* 1919, p. 21)—it would seem that there is here one of the best materials. [*K.B.* Add. Ser. ix., pp. 768–774. "Maize: Its History, Cultivation, Handling and Uses," J. Burtt-Davy, pp. 1–831 (Longmans, Green and Co., London, 1914); "Fermentation Products from Maize," including Industrial Alcohol and Denaturants, by the same author, S. Afr. Journ. Ind., 1922, pp. 245–254.]

Sorghum, Guinea Corn, Dari or **Great Millet** (*Sorghum* spp., *S. Caffrorum*, *S. Durra*, *S. caudatum*, *S. cernuum*, etc.), all tall grasses 6–10–15 feet high, maturing in about 120 days. Cultivation is approximately the same as for maize, but they thrive under drier conditions. It has already been pointed out (*K.B.* 1912, p.121) that this grain, with a starch content (55–64 per cent.) higher than that of Wheat, Rye, Maize or Barley, and yielding approximately 85 gallons of alcohol per ton, is a source of spirit capable of great development. [*K.B.* Add. Ser. ix., pp. 788–806; see also under Stems (p. 201).]

Rice (*Oryza sativa* Linn. var.). This grain is well-known as a raw material for the production of alcoholic beverages, more especially in the East; "Saki," "Samshu," in Hongkong, "Arrack" in India, and "Choum-choum" (Indo-Chinese Brandy) in Indo-China. In China (Szechuan) the rice-husks are used in a mixture. Unhusked barley, Millet (*Sorghum*) and Indian Corn (Maize) (880 lbs. of each), separately ground fine and well mixed, are added to one catty (133⅓ lbs.) of rice husks and distilled (Hosie, Rep. Prov. Szechuan, China, No. 5, 1904, pp. 21–22). Rice comes to maturity in 4 to 5 months and the average yield of grain from a transplanted crop is one ton or more per acre (2400 lbs. of paddy), but it may vary greatly according to soil and methods of cultivation (*K.B.* Add. Ser. ix. p. 867). The average yield of 95 per cent. alcohol is 88 gallons per ton (2nd Memo. Fuel

Res. Bd., 1921). ["The Hindu Method of Manufacturing Spirit from Rice, and Its Scientific Explanation," J. C. Ray, Journ. and Proc. As. Soc. Beng., n.s. ii. 1906, pp. 129–142 (Reprint in Trop. Agric. Ceylon, July, 1907, pp. 29–40); *K.B.* Add. Ser. ix., pp. 862–869; see also under Cellulosic Materials (p. 207)].

(4) Stems.

Grass Trees or **Black Boys** (*Xanthorrhoea Preisii* Endl., and other species). Perennial plants with thick, short arborescent woody stems, and leaves in a dense grass-like tuft at the apex; all the species are confined to Australia. Recent experiments show that the core or inner part of the stem contains about 10 per cent. of sugars which are easily fermentable and yield in alcohol from 0·5 to 1·26 gallons per bushel of 60 lb. Specimens were gathered in September when the yield was at the highest (1·24 gallons of alcohol per bushel), in February (yield 0·8 galls. per bush.) and in June (yield 0·5 galls. per bush.). The average was equivalent to 19 gallons of 95 per cent. alcohol per ton of core, the cost of the raw material for the manufacture of 1 gallon of spirit being estimated at 0·63d. for each shilling which the core would cost per ton delivered at the distillery. See Cellulosic Materials (p. 210). ["Investigations of Grass Trees," Mackinnon, Sci. and Ind., Australia, 1920, pp. 277–287.]

Sago Palms (*Metroxylon Rumphii* Mart.). The **Thorny Sago Palm** of New Guinea, Moluccas, Amboyna and Borneo, is a tree similar in general appearance and conditions of growth to *M. Sagu*, which is the principal source of Sago for this country. The New Guinea palm is being exploited for the production of spirit for motor fuel, called "Natalite," (as in South Africa), an area of 100 sq. miles having been granted to the Australian Natalite Company, with headquarters at Sydney. The washed and dried material (starch) obtained from the trunks is estimated to yield 73 gallons of absolute alcohol per ton (Inter. Sugar Journ., May, 1921, p. 270). The **Spineless Sago Palm** (*Metroxylon Sagu* Rottb.) has a stem 25–35 feet high, 1½–3 feet in diameter at the base (*K.B.* 1894, p. 416). It flowers when about 20 years old after which the main stem dies. It reproduces from suckers. Native of the swampy regions of the East Indies; common in Sumatra and adjacent islands, and in Borneo; cultivated in the Malay Peninsula. Each tree when cut down after from 5–7 years' growth or when about to flower may yield from 4–5 pikuls (approx. 550–650 lbs.) of raw starch or sago. It is recommended as a source of Alcohol. [*K.B.* 1894, p. 416; Add. Ser. ix. p. 722.]

Sorghum Stems. Under this head the only plant to be mentioned on account of sugar-content is the "Sugar Sorghum" or "Sweet Sorghum" (*Sorghum saccharatum*), an annual plant, upwards of 10 feet in height, cultivated in China, India, United States, Niger region, Egypt, etc. It is grown on

a commercial scale in the United States for the extraction of sugar and syrup, as well as for forage. One ton of cleaned stalks is estimated to yield about 12 gallons of 95 per cent. alcohol. In Australia, where the varieties "Early Amber" and "Planter's Friend" are well-known to farmers as forage plants, this sorghum is recommended as a source of alcohol and it is likely to be used for that purpose in future. Taking an average yield as 15 tons per acre, the quantity of alcohol would be 187 gallons from one acre of sorghum, on which basis 80,000 acres would provide the raw material for 15,000,000 gallons of alcohol (Council Sci. and Ind. Australia, Bull. No. 6, 1918, "Power Alcohol," p. 21). [*K.B.* Add. Ser. ix. pp. 798–800.]

Sugar Cane (*Saccharum officinarum* Linn.) is grown in almost all tropical countries, of which Cuba, British India and Java each produce more than a million tons of sugar a year. The molasses is one of the best materials for the production of alcohol for distillation at home, for which purpose over 100,000 tons, chiefly from Cuba, are imported for the use of distillers and as food for stock. In most countries producing sugar a large proportion of spirit is distilled. "Ron" is the name of a motor spirit produced in Peru, by which it is said that one up-to-date sugar factory paid all its expenses, the sugar made representing clear profit (Inter. Sugar Journ., 1920, p. 668). "Espiritu Motor," a denatured alcohol produced in the local distilleries of Cuba and sold side by side with petrol, was being used by upwards of 2000 motor vehicles in Havana in 1922 (West India Comm. Circ., Feb. 15, 1923, p. 76). In Mauritius, where the bulk of the molasses is used as a fertiliser, the distilleries produce rum, chiefly, and in 1921 the output was approximately 2,000,000 litres; but in the same year one of the largest estates in the Colony was installing a distillery and etherification plant designed to turn out 5000 litres of alcohol daily, and it is intended to devote it exclusively to the production of power alcohol, prepared as "Natalite" (Col. Rep. Ann. No. 1149, Mauritius, for 1921 (pub. 1923), pp. 13–14). In Queensland (Council, Sci. and Ind. Bull., No. 6, pp. 20, 21, Melbourne, 1918), tank steamers carry molasses from Cairns in N. Queensland to Brisbane for the production of industrial alcohol (Inter. Sugar Journ., 1922, p. 128). Works for the extraction of industrial alcohol from molasses have been opened at Salt End near Hull. The molasses will be pumped direct from tank steamers into containers in the works, which occupy 15 acres (Chemist and Druggist, April 12th, 1924, p. 526). Many more details in reference to various countries might be given, but the above will be sufficient to show the magnitude of the industry and the possibilities of development. In general a ton of sugar will yield 40 gallons of molasses from which 16 gallons of alcohol of the first quality can be produced (Inter. Sugar Journ., 1919, p. 513), though an average production from cane molasses may reach 69 gallons of 95 per cent. alcohol per

ton (2nd memo. Fuel Res. Bd., 1921, p. 2). [*K.B.* Add. Series ix., p. 779–787.]

(5) Leaves.

Sisal Hemp (*Agave sisalana* Perr.). This well-known fibre plant is a native of Central America. The commercial sources of the fibre are the Bahamas, Turks and Caicos Islands, Java, East Africa (Kenya Colony, Tanganyika, etc.), Bengal, Natal, and Mexico. It is under cultivation in various Colonies in West Africa, West Indies, and Fiji. Mention was made in the previous paper (*K.B.* 1912, p. 124) of the possibility of producing a spirit from the waste fleshy matter of the leaf scraped off in the process of extracting the fibre, and from the juice of the leaf, in Yucatan, an important centre of the industry. A similar possibility was reported in 1920 for the Bahamas Industry. In the replies to the Questionnaire sent out from the Colonial Office in April, 1920, it was shown that Sisal refuse in the Bahamas is the only waste product of importance in the West Indies, and on the present method of working the Sisal would produce about half a million gallons of 95 per cent. alcohol a year (Journ. Bd. Agric. Brit. Guiana, April, 1921, p. 93). In Yucatan the weight of fibre obtained from 1000 leaves is from 26 to 30 kilog., with refuse of from 92–96 per cent. of the leaf-weight according to the time of year. In the dry season the average weight of a leaf is from 400–420 gm., and in the rainy season from 700–725 gm. The sap obtained by pressing the leaves varies in composition according to the season, the maximum density observed (May 20th) was 1·104, with 14·6 per cent. hydrolyse in the whole soluble material. These figures show for 1,000 medium leaves in the first case 36·5 kilogs. of sugar (22 litres of absolute alcohol), and in the second case 21·6 kilogs. of sugar (13 litres of alcohol), (Trop. Life, April, 1912, pp. 67–68 ; May, 1912, pp. 86–88).

In Kenya experiments to ferment Sisal waste have been made, and a preliminary analysis of the juice of leaves from the coast gave about the same value for the sugar-content as was obtained for the highland material, namely, not more than 3 per cent., and further experiments go to show that the whole problem is one of careful research (Ann. Rep. Dept. Agric., Kenya, 1914–1915, p. 105). It would seem that hitherto it has been impossible to use the juice of the *Agave* as a source of sugar, although it may contain 10–15 per cent. of sucrose, because of the quantity and nature of the impurities present, and two factories erected in 1909 in Yucatan for utilising the juice are stated to have failed on account of the difficulties of fermentation. A recently discovered electrolytic method of purification of cane-juice has been suggested for application to *Agave* leaves (Inter. Sugar Journ., 1921, pp. 418, 470). It is claimed that sugar of an excellent quality has been produced from the juice of the Agaves, and Delafond (who has patented

in all the sugar countries of the world an electrolytic treatment for the clarification of the juice of sugar canes, sugar-beets, sorghum, etc.) has now successfully applied this process to the juice of the *Agave*, and has obtained some very fine sugar, perfectly crystallised. He expresses the opinion that by its application a great alcohol industry can be established (Inter. Rev. Agric. Rome, Oct. 1921, p. 1330).

New Zealand Hemp or **Flax** (*Phormium tenax* Forst.). The chief commercial sources are limited to New Zealand and St. Helena. The plant has been tried in England, Scotland, Ireland and elsewhere, but it does not appear to have succeeded anywhere on a commercial scale. The fibre is obtained from the leaves and it has recently been proposed to utilise the refuse in the manufacture of alcohol. It is reported that in New Zealand a plant is being established to distil alcohol from the juices of flax which contain fermentable sugars, and in this connection the following particulars as to analyses and production of alcohol, for which I am indebted to Mr. L. A. Boodle, may be of interest. " The chemistry of the fresh leaf of *Phormium tenax* was studied by A. H. Church, and the results of his analyses are quoted in a small book by Hector on ' Phormium tenax as a fibrous plant,' published in New Zealand (2nd ed. 1889, pp. 62–72). In relation to the subject under consideration, however, importance attaches rather to the percentage of sugar in the refuse (after extraction of the fibre), than to the percentage in the leaf. Data as to the percentage of sugar in the refuse do not appear to be available, but for practical purposes the need of such data has been greatly diminished in the case of *Phormium* grown in New Zealand, since determinations of the amount of alcohol which can be obtained from the refuse have been carried out in that country. The results are indicated by E. H. Atkinson (N. Zealand Dept. Agric. Bull. No. 95, n.s. June, 1922) who states that Professor T. H. Easterfield found that from 50–60 per cent. of juice can be squeezed from the fresh refuse. This juice ferments readily, and different samples have yielded from 2–5 per cent. of alcohol. So far no application of these promising results has been made on a commercial scale. Dr. E. J. Butler, who visited New Zealand last year (1924), informs me that the largest phormium-fibre mill produces 40 tons of waste (known as " vegetation ") per day when the mill is working at full pressure. A large quantity of alcohol could therefore be obtained by fermentation of the juice, if the working expenses were low enough to make the undertaking a commercial success."

There is no information available as to whether the same process as applied to *Agave* leaves has been experimented with, but it would appear to be worth a trial. [*K.B.* 1919, pp. 169–177.]

Shea-Butter Tree (*Butyrospermum Parkii* Kotschy). Leaves from the Gold Coast have been examined at the Imperial

Institute, but the results of the investigation show that the leaves do not contain sufficient fermentable matter to render them suitable for the production of alcohol (Rep. Agric. Dept. Gold Coast, 1922–23, p. 86).

(6) Inflorescences.

Nipa or **Nipah Palm** (*Nipa fruticans* Thunb.). A low, branched palm thriving in low-lying places near rivers subject to tidal influence in the Eastern Tropics. Propagated from seeds or suckers; plants come to maturity for tapping in about 5 years. Some particulars of yield were given in the previous paper (*K.B.* 1912, p. 125) in special reference to the Philippines, where the production of alcohol from this palm is an established industry. Investigations are being made in the Federated Malay States, where nearly 20,000 acres are estimated to be available, and it is reported that the Natalite Motor Spirit Company of Australia has acquired the rights for the production of alcohol-ether fuel from Nipah palm in the Dutch East Indies, Straits Settlements and the Federated Malay States (Inter. Sugar Journ. Oct., 1921, p. 590). In 1919 the British North Borneo Company discussed the possibilities of establishing a Nipa Alcohol Industry within their territory where they have at least 300,000 acres of palm groves at very accessible points, and practically unlimited areas of Nipah swamp are available with a production of at least (estimating 100 gallons of sap to produce 6–7 gallons of alcohol) 250 gallons of spirit per annum for every acre under management (Foxworthy & Matthews, seq.). ["Mangrove and Nipah Swamps of British North Borneo," F. W. Foxworthy and D. M. Matthews in Bull. No. 3, 1917, Dept. of For., Govt. of B.N. Borneo, pp. 18–22. "The Nipah Palm as a Source of Alcohol," Bull. Imp. Inst., 1922, pp. 315–325. "*Nipa fruticans*", *K.B.* Add. Ser. ix. pp. 715–717. "Preliminary and Interim Report on Investigations on the Production of Alcohol from Nipah Palms," B. J. Eaton and J. H. Dennett, Mal. Agric. Journ., March, 1923, pp. 47–63.]

Mahua, Mahwa, Mowra, or **Mhoura** (*Bassia latifolia* Roxb.). A tree abundant in the Central Provinces of India, especially in Hyderabad and Indore, the Native Rulers of which States obtain a large revenue from the production of the flowers of this tree for food and spirit. Mahwa flowers since 1877 have been known to be a good source of spirit (*K.B.* 1912, p. 126). They have recently attracted considerable attention for the production of spirit and acetone, of which during the late war they were an important source, and at the present time there is a proposal under consideration to exploit them in India, subject to Company conditions, for power alcohol. It has been estimated that in the Hyderabad State alone there are sufficient trees to produce 700,000 gallons of proof-spirit per annum at a cost of 30s. per ton for collecting, drying, and delivery

of the flowers to a factory in the zone of growth. By native methods 1 maund (82⅔ lbs.) of dried flowers yields 2·12 gallons of proof-spirit (2·88 gallons per cwt.), but in England it was found that over 6 gallons per cwt. could be obtained (Inter. Sugar Journ., 1920, p. 282). Another estimate (l.c. p. 414) for collecting and drying is at least 60s. per ton, and the yield from an existing factory over a long period is slightly under 60 gallons per ton of flowers. Seeing that the flowers are of importance in India as a food-stuff, for which in pre-war days the local price was Rs. 42 per ton, rising to Rs. 175 per ton in 1919 (l.c.), it is suggested that the successful production of spirit would depend largely on the price for collecting and the local value for food. Ryan (seq.) advises a system of cultivation whereby 15 to 20 large Mhoura trees could be grown per acre with "jungle-wood" species intervening to yield material for fuel, or they may be cultivated on open land outside forested areas such as grazing land. He also states that waste areas, such as exist in the Khaira district in Guzerat where there are no State Forests and where thousands of Mhoura trees can be seen growing wild, might be devoted to the purpose of spirit production. The trees become productive at from 20–25 years, continuing for about 200 years, and a tree will yield 200 to 300 lbs. of flowers in a year. The so-called "French Brandy" was at one time distilled from flowers exported from Bombay to France (*K.B.* 1912, p. 126), but to-day there does not appear to be any trade in them, and their use for distillation is probably confined to India.

Bassia longifolia Linn., to which the above particulars also apply, is a similar tree, more common in S. India. The two trees are a valuable source of oil, which is obtained from the kernels, and is suitable for soap-making, for which purpose it is used locally. There is also a large export trade in the seeds to this and other European countries, under the name of "Mowra" seed. ["Suggestions to introduce Special Working Plans for the Exploitation of *Bassia latifolia* and *Bassia longifolia* Linn. in India," G. M. Ryan, Ind. Forester, July, 1918, pp. 291–315. "The Bassia Tree and Its Products," Imp. Inst. Bull., 1919, pp. 401–406.]

(7) Cellulosic Materials.

Considerable interest has been taken recently in the production of spirit for power purposes under this head. Apart from wood or woody substances (hardwoods, sawdust, peat, etc., described in the previous paper, *K.B.* 1912, pp. 126–129, q. v.), almost every fully developed plant might be included. The possibility of using vegetation, especially that of the tropical and sub-tropical portions of the British Empire, as a source of alcohol has been engaging the attention of the Fuel Research Board, and the experiments so far carried out have resulted in a process for converting the pentosans into pentoses and the

fermentation of the latter into alcohol. The commercial prospects of the process have yet to be determined.

Numerous **Grasses** and **Sedges** might be suggested, but it may be sufficient to mention two that would supply material in large quantities. **Rice** (*Oryza sativa* Linn.), of which it is reported that large-scale experiments upon waste rice-straw have been carried out by the Burma Oil Company (Journ. Roy. Soc. Arts, 1921, p. 472), and a patent for the treatment (Bedford and Rogers) is recorded (Inter. Sugar Journ. 1920, p. 660). **Papyrus** (*Cyperus Papyrus* Linn.), a tall sedge which, as forming the main element of the Sudd region of the Nile, has recently come under review for fuel, etc., in the Sudan, Kenya Colony and Zululand, and it might also be included for experiment as a source of alcohol. [Cyperaceae and Gramineae, *K.B.* Add. Ser. ix., pp. 760–880.]

Peat. In 1919 the Inter-Departmental Committee in the "Production and utilisation of alcohol for Power and Traction Purposes" (H.M.S.O., 1919—Cmd. 218, p. 6) reported that "no satisfactory method for the utilisation of peat as an economic source of power alcohol has been brought to our notice; we are, however, of opinion that in connection with researches into the use of peat for various purposes, its potential value as a raw material for the manufacture of such alcohol should not be overlooked." In 1921 the Fuel Research Board issued a special report on the findings of the Irish Peat Inquiry Committee (appointed 1917) and subsequent work on the general peat problem. Johnson (seq. pp. 2, 10) describes the extraction of alcohol from turf, and the destructive distillation of peat. He quotes the method of Kapesser (1891) of obtaining sugar containing fluids and alcohol from the turf, by which 1000 kilog. of dry turf gave 62–63 litres of alcohol, and further points out that as the source of alcohol is the starch and cellulose of the *Sphagnum* leaf and the stem, the quantity of alcohol obtained naturally decreases as the *Sphagnum* or "Peat-Moss" becomes more and more decomposed. There are in Ireland 1861 sq. miles of bog-land; the beds, sometimes of a thickness of 40 ft., on an average 25 ft., are chiefly used for fuel. The average yield of alcohol (of 95 per cent.) from peat is given in the 2nd memo. by the Fuel Research Board (1921, p. 2) as 15 gallons per ton. Peat has been the subject of extensive and careful enquiry for many years, as will be seen from the following references: ["Peat and Its Products," W. Fream, Journ. Roy. Agric. Soc. iv. 1893, pp. 751–778. "Report on the Manufacture of Fuel, Moss-litter and other Products of Peat," Consular Rep., No. 2, Commercial, 1893 (H.M.S.O.—C. 6913). "The Irish Peat Question," T. Johnson, Econ. Proc. Roy. Dublin Soc., i. Nov., 1899, pp. 1–72. "Reports upon the Irish Peat Industries," H. Ryan, *ibid.*, July, 1907, pp. 371–420, including "Preparation of Alcohol from Turf," pp. 419–420: Aug. 1908, pp. 465–546. "Utilisation

of Peat," Bull. Imp. Inst., 1905, pp. 166–176. "Commercial Peat: Its Uses and Possibilities," F. T. Gissing, pp. 1–191 (Charles Griffin and Co., Ltd., London, 1909). "Quality and Value of Important Types of Peat Material, A Classification of Peat based upon its Botanical Composition and Physical and Chemical Characteristics," A. P. Dachnowski, U.S. Dept. Agric. Bull. No. 802, 1919, pp. 1–40. "The Winning, Preparation and Use of Peat in Ireland," and other Reports by the Fuel Research Bd. (H.M.S.O., 1921).]

Seaweed.—The production of alcohol from Seaweed is not by any means new. Stanford (Journ. Soc. Arts, 1862, pp. 193–194) made experiments in 1861, and found that 100 tons of seaweed (kelp, species of *Laminaria*, etc.) yielded 102 gallons of napthalene. Thorpe (Perf. and Essential Oil Record, Oct., 1918, p. 263; Pharm. Journ. Oct. 26th, 1918, p. 203) who suggests the application of Stanford's methods of collection and preliminary treatment of seaweed at the present time, states that 100 lbs. of "red-wrack" (*Laminaria Cloustoni* Edm., which is found on the northern coasts of Great Britain and Ireland), when "dried to a moisture content of 10 per cent. and heated for a short time with weak sulphuric acid and the acidity still further reduced after cooling, may be fermented with brewer's yeast and is then capable of yielding about 6 litres of alcohol on distillation." The handling of seaweeds on a large scale is of common occurrence for use as manure, extraction of kelp ("seaweed ash") and iodine, and for the preparation of food, and many of the species dealt with have proved promising sources of alcohol. Kelp is abundant on our own coasts, on the Pacific coast, where for instance the area of the kelp beds along the United States Pacific Coast is estimated at nearly 400 square miles (Bd. of Trade Journ. Dec. 4th, 1916, p. 836), and it is probably more or less common on every coast from the Arctic to the Antarctic, so that the supply at least from this source might be regarded as unlimited, and provided alcohol can be produced successfully on a commercial scale kelp would seem to be a source well worthy of development. ["On the Economic Applications of Seaweed," E. C. Stanford, Journ. Soc. Arts, 1862, pp. 185–199. "Clare Island Survey": Part 15, "Marine Algae," A. D. Cotton, Proc. Roy. Irish Acad., 1912, pp. 1–178. "The Cultivation of Seaweed in Ireland," Journ. Dept. Agric., Technical Instruction for Ireland, xv. 1915, p. 546. "The Composition and Use of certain Seaweeds," Journ. Min. Agric. xxii. 1916, pp. 1095–1107, with analyses of *Laminaria digitata* Lamour, *L. digitata* var. *stenophylla* Harvey, *Ascophyllum nodosum* Lejol., *Fucus vesiculosus* Linn. and *F. serratus* Linn. "Production of Alcohol for Motor Fuel from Seaweed," Inter. Sugar Journ., Feb., 1922, p. 105.]

Lichens.—In Scandinavia the "Reindeer Moss" (*Cladonia rangiferina* Hoff.) has been used for the manufacture of alcohol

since between 1860 and 1870 (Weisner, Die Rohstoffe Pflanzen. ii. p. 132). By boiling the plant in dilute sulphuric or hydrochloric acid, a liquid is obtained which, after neutralisation of the free acid, is fermented, and the alcohol is then obtained by distillation. This lichen has a wide geographical range; in Britain it is common on hills and heaths in lowland, sub-alpine and alpine districts and in Lapland it covers barren plains where it is the food of the reindeer during winter.

Prickly Pear Stems, *Opuntia stricta* Haw. (*O. inermis* DC.), and other species of *Opuntia*. The immense quantities of these plants available in hot, dry countries such as Australia, South Africa and India, were referred to under Fruits (page 194). They prove such pests that many thousands of pounds are expended annually by the Governments of the various countries in efforts to get rid of them, though at the same time the methods of destruction, crushing with heavy rollers, introduction of Cochineal Insect, the use of chemicals, fire, etc., have also included the possible discovery of a commercial use for the plant, either as a source of Potash, as fodder for stock, or for the production of industrial alcohol. It would seem, however, that so far no practical solution has been arrived at, and experiments are still in progress. An investigation has been carried out at the Desert Laboratory, Tucson, Arizona, by Herman A. Spoehr (No. 287, Carnegie Institution, Washington, 1919, "The Carbohydrate Economy of Cacti," pp. 1–79), who states "the greater part of the work was done with *Opuntia phaeacantha* Engelmann (*O. Blakeana* Rose). Other species were also used but the results do not differ materially from those obtained with this plant" and that "the Cacti consist essentially of carbohydrate material; compared to this the protein and fats are present only in small quantities; roughly the fresh material of the growing and mature joints contain carbohydrates hydrolizable with one per cent. HCl, 2 per cent. (growing) and 10 per cent. (mature), and cellulose 1 per cent. (growing) 3 per cent. when mature." Cross & Dorée ("Researches on Cellulose," iv. 1922, p. 225) place "Prickly Pear" (*Opuntia Ficus-indica*) with Seaweed (*Laminaria digitata*: *Fucus vesiculosus*) and Papyrus Pith (*Cyperus Papyrus*) as "Natural hemicelluloses," and their investigations in the bacterial resolution of celluloses show, with the varieties of cellulose tested, that "any carbohydrate will serve as food for the cellulose-destroying organisms, also that the various carbohydrates yield similar products, and in similar proportions under identical conditions." In Queensland, analyses of the "Pest Pear" (*Opuntia inermis*) carried out on the green parts of the plants by J. C. Brunnich (Bull. No. 12, Inst. Sci. & Ind. Australia, 1919, p. 22) showed that "the total sugar-content calculated as dextrose was 0·64 per cent. Experimental work on the production of alcohol from prickly pear, under as perfect conditions as possible for the fermentation and distillation, gave a yield of alcohol equal to 0·5 per cent.

of the weight of the plant used. When the cost of labour for cutting and collecting, the cost of crushing and fermenting and finally the cost of concentrating alcohol from such dilute solutions as yield only 0·5 per cent. of spirit are all taken into consideration, the problem does not appear to be capable of economic successful solution." The percentage of moisture in *Opuntia inermis* is 89·7, leaving 10·3 per cent. of dry matter, and the quantity of prickly pear necessary for the production of 1 ton of sugar is 156 tons (Bull. No. 6, Council Sci. & Ind. Australia, 1918, " Power Alcohol," p. 34).

Various products of a secondary character in certain industries have been suggested as possible sources of motor spirit, as Jute butts (*Corchorus capsularis*) cut off in the preparation of Jute fibre in India ; Maize cobs (*Zea Mays*) ; Cotton stalks (*Gossypium* spp.) ; Vine shoots (*Vitis vinifera*), the ensilage made immediately after the vintage (Comptes Rendus de l'Acad. d'Agric., Paris, March, 1919, pp. 334–340) ; and residue from farm crops and various weeds in England (Nature, April 7th, 1921, p. 170). Experiments at the Columbus (Ohio) garbage reduction works showed that one ton of green garbage will yield 4·8 gallons of 95 per cent. alcohol of satisfactory quality (Exper. St. Record, U.S. Dept. Agric., 1917, pp. 590–591).

Amongst Forest Products the distillation of woods for the production of methyl alcohol is well established and of growing importance. The distillation of the outer part of the stems of " Grass Trees " (*Xanthorrhoea* spp.) has been advocated in Australia, the products being much like those of ordinary wood distillation, tar, acetic acid, methyl alcohol. The following note in reference to the production of " ethyl alcohol " from the " Western Larch " (*Larix occidentalis* Nutt.) may be of interest. This Larch is a native of western North America, where it is a valuable timber tree. The wood may be classed with Pine and Spruce as soft, and therefore not so favourable for the production of wood spirit as hardwoods such as Hawthorn, Maple, etc. " The fact that Western Larch is so productive a source of ethyl alcohol is of special interest to the lumber industry, since it affords a means of utilising not only the waste but also the large quantities of butt-logs now left in the woods. Experimental fermentation of sugars obtained indicate that this wood is one of the most valuable sources of ethyl alcohol. The Forest Products Laboratory of the United States Forest Service, has succeeded in converting into alcohol, not only the sugars obtained from hydrolysis of the cellulose, but also a large proportion of the galactose-sugar obtained from the galactan in the wood. The yeast used in the laboratory experiments is a pure strain culture of Hungarian ' beer yeast,' which has proved very efficient in the fermentation of sugars resulting from the hydrolysis of wood. The total alcohol yield from Western Larch was found to be at least 33 gallons per ton of dry wood.

This was almost 10 gallons per ton greater than that of any other wood studied." (Raw Materials Review, " Ethyl-Alcohol from Larch ", Nov. 1922, p. 27).

Motor Fuels containing Alcohol.—Numerous patents have been taken out for various mixtures for use as motor spirits, and under various names, perhaps the one more generally known being the mixture of alcohol-ether called " Natalite " (see under Molasses, Nipah, etc.). Reference may also be made to " Springbok " (under Prickly Pear), " Penrol " (under Maize), " Acetol " (under Sweet Potato), " Sylvestrique " (Sylvestrene or Oil of Turpentine in the mixture) patented in Mauritius, 1918 (Inter. Sugar Journ., 1921, p. 503), and there is also a mixture containing alcohol, called " Discol," made by the Distillers' Company in this country. Experiments have been made with various mixtures in the Chemical Laboratories of Manchester University (Rep. Inter-Dept. Com. on the Production and Utilisation of Alcohol for Power Purposes, p. 5) and by the Empire Motor Fuels Committee (2nd memo., Fuel Res. Bd., 1921, p. 15). See also the Report of the Empire Motor Fuels Committee (Inst. Automobile Engineers, London, 1924).

Denaturants.—Alcohol before it can be used as an ingredient of a motor spirit must be denatured. The matter of denaturing is regulated by law ; the official regulations are readily accessible and for this country are contained in Statutory Rules and Orders No. 1318 of 1921, under the head " Power Methylated Spirits." [*K.B.* 1912, pp. 128–129 ; " Alcohol Denaturants," J. Dobbie, Inter. Sugar Journ., 1920, p. 654 from Journ. Soc. Chem. Ind., 1920, pp. 86–88.]

Amongst the suggested denaturants of vegetable origin are " Tobacco Oil," fatty acids from " Rape " (*Brassica* spp.) or " Linseed " (*Linum usitatissimum* L.) or " Castor Oil " (*Ricinus communis* Linn.) with petroleum distillate, " Resin Spirit," " Pine Oil "—with benzol and nitro-benzol—(allowed by the Inland Revenue of Canada instead of methyl-alcohol, owing to the high cost), " Citronella " (*Cymbopogon Nardus* Rendle) in Ceylon and " Eucalyptus Oil " (*Eucalyptus* spp.) in New South Wales, all, it should be understood, in the experimental stage.

It should be added that other important factors, such as transport, labour, cost of raw material, fuel for the distilleries, and various conditions that can only be decided locally, must be taken into consideration when estimating the probability of establishing an industry.

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Index to plants and subjects.

Figures in italics refer to *Kew Bull.*, 1912; those in roman refer to the present paper.

XXV.—CRITICAL NOTES ON GALAPAGOS PLANTS.

("St. George" Pacific Expedition, 1924.)

L. A. M. Riley.

The flora of the Galapagos is of unusual interest for two reasons. In the first place the proportion of endemic species is very high—41·5 per cent. according to the latest computation—and many of these are endemic, not only in the archipelago as a whole, but in single islands. Secondly, to quote Sir Joseph Hooker,* "this group possesses the rare advantage of being one whose vegetation has never been interfered with by any aborigines of the human race; and it is only very lately that the operations of man, or of animals introduced by his means, have disturbed the indigenous Flora, and that to a very limited extent only."

* Trans. Linn. Soc. xx. 235 (1847).

The history of botanical collecting in the Galapagos may be said to commence with the visit of the "Beagle" in 1835, from Sept. 15 to Oct. 20, when Darwin landed on Albemarle, Charles, Chatham, and James Islands, discovering seventy-eight species of plants new to science. Previously, small collections had been made by Douglas and Scouler on James Island in 1825, and by Macrae on Albemarle in the same year. In January, 1846, during the visit of the "Herald," Edmonston collected on Charles, Chatham, and James Islands. These collections were determined by Sir Joseph Hooker, who embodied the results in "An Enumeration of the Plants of the Galapagos Archipelago," published in 1847.* Here also were included a few plants collected by Cuming in 1829 on some island unascertained, and by Abel Du Petit-Thouars on Charles during the stay of the "Venus" in 1838. Hooker in his "Enumeration" gives a list of 223 flowering plants and ferns, but in his paper "On the Vegetation of the Galapagos Archipelago,"† published in the same year, he gives the total as 253 species of which 123 are endemic.

The next important collection was made by Andersson in May, 1852, during the voyage of the "Eugenie." He visited the four islands already known botanically, and, in addition, collected on Indefatigable. His collection was the largest hitherto made, and in 1855 he published the second enumeration of the flora of the Galapagos.‡ Here the total of flowering plants and ferns was brought up to 374, of which 79 were described as new.

Between 1852 and 1891 the collections made in the Galapagos were few, and, comparatively, of little importance. Mention may be made of Dr. A. Habel, who in 1868–69 collected on the unexplored islands of Bindloe and Hood as well as on the previously known islands. He brought back 69 species, of which 28 specimens are in the Kew Herbarium. His collection included two species new to science.

In 1891 a large collection was made by Dr. Baur, who visited all the islands of the archipelago with the exception of Culpepper, Narborough, Seymour, and Wenman, and in 1898 the Hopkins-Stanford Expedition spent six months in the group, the botanists, Snodgrass and Heller, collecting on every island. In view of the wealth of material thus brought to hand, Dr. B. L. Robinson undertook the third enumeration of the flora of the Galapagos.§ His list of vascular plants comprises 590 species, of which 239 are endemic, and of these 130 are confined to a single island.

The fourth and most recent enumeration of the vascular flora is that of Stewart,‖ who, as botanist, accompanied the Expedition of the Californian Academy of Sciences to the Galapagos, which remained in the archipelago from Sept. 24th,

* Trans. Linn. Soc. xx. 163–233 (1847). † l. c. 235. ‡ Vet.-Akad. Handl. 1855, 63–256. § Proc. Amer. Acad xxxviii. 77–269 (1902). ‖ Proc. Calif. Acad. ser. 4, i. 7–288 (1911).

1905, to Sept. 25th, 1906. During this period all the islands were visited at least once, and some of them on two or three different occasions. Stewart's account is the most complete hitherto published. He records the total number of species, varieties, forms, and indeterminate species as 682, of which 67 are indeterminate and 252 are endemic.

Since the Californian expedition the Galapagos do not seem to have been visited botanically until the arrival of the Scientific Expeditionary Research Association's yacht "St. George" in July, 1924. The "St. George" remained in the group from July 25th until August 7th, the scientific party landing on the islands of Albemarle, Charles, Indefatigable, and James. As the writer had unfortunately been compelled to return to England on medical advice, collecting was kindly carried out by the other scientists in addition to their regular duties, and a collection of 70 numbers was made, comprising 53 species and varieties, which are enumerated below. Of these, three are described as new to science (*Polygala Sancti-Georgii*, *Acacia insulae-Iacobi*, and *Lycopersicum Cheesmanii*). A new variety of *Dalea tenuicaulis* was found on Charles (var. *goniocymbe*). *Psilotum triquetrum*, never before recorded anywhere in the archipelago, was found on James, and four new records for individual islands were made (*Gossypium Darwinii*, *Castela galapageia*, *Pectis subsquarrosa* and *Ipomoea linearifolia*). *Ipomoea linearifolia*, found on Indefatigable, is a peculiarly interesting record, as it was collected by Darwin on James in 1835, and has not been recorded since then by any other collector in the Galapagos. Material of the three species described as new existed already in the Kew Herbarium and elsewhere, but had either been wrongly named or had remained undetermined. A fourth new species is described below (*Scalesia Stewartii*); the material of this was not collected by the "St. George" expedition, but by Stewart in 1906, and wrongly referred by him to *S. atractyloides*. I have also described a new variety of *Tournefortia pubescens* (var. *Bauri*); the material of this was collected by Baur on Chatham Island.

The collection includes material of five previously described species hitherto unrepresented in the Kew Herbarium (*Scalesia affinis*, *S. villosa*, *Asclepias angustissima*, *Tournefortia pubescens* and *Peperomia obtusilimba*).

My thanks are due to Professor A. C. Seward for enabling me to examine certain type specimens of Darwin's plants in the Cambridge University Herbarium.

The first set of herbarium specimens has been presented by the Scientific Expeditionary Research Association to Kew, and the second set to the British Museum.

Polygalaceae.

Polygala Sancti-Georgii *Riley*, sp. nov.; affinis *P. galapageiae* Hook. f., foliis late spathulatis, alis maioribus carinam multo superantibus differt.

Fruticulus circiter 0·5 m. altus, omnino glaber (semine excepto). *Ramuli* tenues, rigidi, subteretes, divaricati, glauci. *Folia* conferta, subimbricata, late spathulata, 7·5–9 mm. longa, 5–7 mm. lata, rotundata vel subtruncata, cuspidata, breviter petiolata, grosse pellucido-punctata, coriacea, glauca. *Racemi* ad 7 cm. longi. *Bracteolae* subulatae, 0·5 mm. longae, mox deciduae; pedicelli 1 mm. longi. *Flores* lilacini [mauve]. *Sepala* late ovata, 1·75–2·25 mm. longa, 1·25–1·75 mm. lata, rotundata. *Alae* elliptico-ovatae, 6·5 mm. longae, 3·5 mm. latae, obtusae, 5–7–nerviae. *Carina* 4 mm. longa. *Petala superiora* oblonga, 3·5 mm. longa, 1·25 mm. lata, rotundata. *Capsula* 3·5 mm. longa, 2 mm. lata. *Semina* obconica, nigra, griseo-sericea, 2·5 mm. longa, 0·75 mm. lata, arillo fulvo 0·75 mm. longo ad medium partito.—*P. obovata* var. *latifolia* Andersson in Vet.-Akad. Handl. 1855, 231.

Galapagos: Charles Island, fl. August, *Hicks in Riley* 424 (type in Herb. Kew.); *Andersson.*

Undoubtedly very nearly related to *P. galapageia* Hook. f., which seems to be a variable plant, but the absence, so far as I am aware, of any transitional forms as regards the foliage between that species and *P. Sancti-Georgii*, and the larger flowers with proportionately larger wings of the latter seem to indicate that we have here a distinct species.

P. galapageia *Hook. f.* in Trans. Linn. Soc. xx. 233 (1847); Andersson, Freg. Eugenies Resa, Bot. 100, t. 10, f. 1.; Robinson in Proc. Amer. Acad. xxxviii. 160 (1902); Stewart in Proc. Calif. Acad. i. 85 (1911).

Albemarle; Tagus cove, fl. August, no. 443. Indefatigable; base of crater, fl. July, no. 401.

P. galapageia var. **insularis** (*A. W. Benn.*) *Robinson* l.c. 161; Stewart l.c. 86.—*P. insularis* A. W. Benn. in Journ. Bot. 1879, 204. *P. obovata* Hook. f. l.c., non St. Hil.; Andersson l.c. 99, t. 10, f. 2 (var. *angustifolia*).

Indefatigable; on a sandy patch near the coast, fl. July, no. 400.

I have followed Robinson in treating *P. insularis* as a variety of *P. galapageia*, but it seems to be connected with the type of the latter by a series of intermediate forms, and it is questionable whether it is worthy of even varietal rank.

Malvaceae.

Gossypium Darwinii *Watt*, Wild and Cultivated Cottons of the World, 68, t. 4 (1907).—*G. barbadense* Robinson l.c. 173, partim, non L.

Albemarle; Tagus cove, fl. Aug., no. 440.

According to Watt this has been collected previously in James and Chatham Islands only.

Sterculiaceae.

Waltheria reticulata *Hook. f.* in Trans. Linn. Soc. xx. 231; Robinson l.c. 176; Stewart l.c. 104.

Albemarle; Tagus cove, 240 m., fl. Aug., no. 439. Charles; fl. July, no. 412, no. 425. Indefatigable; salt lagoon near coast, fl. July, no. 404.

These specimens, though showing a small range of variation, are all referable to the type and do not seem to represent any of the forms described by Robinson. Typical *W. reticulata* has not been previously recorded for Indefatigable Island.

Simarubaceae.

Castela galapageia *Hook. f.* in Trans. Linn. Soc. xx. 229; Robinson l.c. 158; Stewart l.c. 82.

James; 120 m., fl. and fr. July, no. 398.

Hitherto, typical *C. galapageia* has been recorded only from Albemarle, Chatham, and Hood Islands.

C. galapageia forma **jacobensis** *Robinson* l.c. 159; Stewart l.c. 83.

James; fl. July, no. 399.

Celastraceae.

Maytenus obovata *Hook. f.* in Trans. Linn. Soc. xx, 230; Robinson l.c. 170; Stewart l.c. 96.

Charles; near seashore, fl. and fr. Aug., no. 428. James; James Bay, fl. and fr. July, no. 386.

The specimens from James have narrowly obovate leaves and minutely pubescent young branchlets, petioles, and pedicels.

Leguminosae.

Acacia insulae-Iacobi *Riley*, sp. nov.; affinis *A. tortuosae* Willd., a qua ramulis parum tortuosis, pinnis paucioribus et remotioribus, foliolis paucioribus sed multo maioribus, capitulis solitariis, omnino multo glabrior differt.

Arbor ramosa, 3·6 m. alta. *Ramuli* subtortuosi, glabri, striati, lenticellis conspicuis quasi-tuberculatis. *Folia* 3-juga rhachi 1·3–1·8 cm. longa sparse pubescenti glandulas orbiculares inter juga duo superiora glandulam ellipsoideam infra jugum infimum gerenti; pinnae 5–7 mm. remotae, utrinque 5–10 foliolatae rhachillis 1·5–2·5 cm. longis; foliola oblonga, 0·4–1 cm. longa, 1–4 mm. lata, obtusa vel rarius subacuta, basi oblique rotundata, infra valde reticulata, glabrata, basi satis ciliata. *Stipulae* spinescentes, 5–8 mm. longae, minute pubescentes vel glabratae. *Pedunculi* axillares, solitarii, circiter 4 cm. longi, usque ad involucellum glabrati, supra involucellum hispidi; involucellum infra capitula immatura 3–5 mm. distans. *Capitula* globosa circiter 1 cm. diametro. *Calyx* 2·25 mm.

longus, ut corolla glaber, lobis obtusis. *Corolla* 3·5 mm. longa lobis subacutis. *Stamina* basi in tubum 0·5 mm. longum coalita, in toto 4·5 mm. longa. *Ovarium* elliptico-oblongum, 1·25 mm. longum, 0·5 mm. diametro, stipite 0·5 mm. longo; stylus 3 mm. longus; ovula circiter 15. *Legumen* (ex specimine minibus Scouleri descriptum) submoniliforme, parum arcuatum, 11–13 cm. longum, sparse pubescens vel glabratum; semina 5–10.— *A. tortuosa* var. *glabrior* Hook. f. in Trans. Linn. Soc. xx. 229, nomen nudum, quoad specimina Scouleri.

Galapagos: James Island; in ravine near the sea shore, fl. July, *Penny in Riley* 391 (type in Herb. Kew.); *Scouler* (in Herb. Hook.).

This is probably the "*Acacia sp.*; James Island, Snodgrass and Heller 398 (hb. Gr.)" referred to by Robinson in Proc. Amer. Acad. xxxviii. 147, as "near *A. tortuosa* but with larger leaflets." I have not seen the specimen. The specimens in Hooker's Herbarium collected by Dr. Sinclair at Guayaquil and labelled *Acacia tortuosa* W. β *glabrior* in Bentham's writing differ in the longer spines, more hairy leaf-rhachis, and smaller leaflets. There are no flowers, and it seems preferable not to refer these Guayaquil plants to *A. insulae-Iacobi*.

A. macracantha (*H.B.K.*) *Willd.*; Robinson l.c.; Stewart l.c. 68.

Albemarle; Tagus cove, in valleys and on hill-tops, 240 m., fl. Aug., no. 450. James; 120 m., fl. July, no. 397.

Cassia picta *G. Don*; Robinson l.c. 149; Stewart l.c. 70.

Albemarle; Tagus cove, fl. Aug., no. 441, no. 449.

Dalea tenuicaulis *Hook. f.* var. **goniocymbe** *Riley*, var. nov.; a typo floribus minoribus, carinae petalis margine posteriori inferiori valde angulato nec leviter curvato apice obtusis nec rotundatis, tubo staminali 4 mm. nec 2·5 mm. longo recedit.

Charles; 60 m., fl. July, *Hicks in Riley* 420 (type in Herb. Kew.).

Typical *D. tenuicaulis* does not appear to have been recorded for Charles Island, though it is found on Albemarle and Chatham Islands.

Rhizophoraceae.

Rhizophora Mangle *L.*; Robinson l.c. 182; Stewart l.c. 116.

Albemarle; Tagus cove, fl. Aug., no. 444.

Combretaceae.

Laguncularia racemosa (*L.*) *Gaertn.*; Robinson l.c. 183; Stewart l.c. 118.

Indefatigable; Conway bay, fl. July, no. 408.

Ficoidaceae.

Sesuvium Edmonstonei *Hook. f.* in Trans. Linn. Soc. xx. 221 ; Robinson l.c. 144 ; Stewart l.c. 64.

Charles ; on rocks by the sea shore, no. 417.

S. Portulacastrum *L.* ; Robinson l.c. ; Stewart l.c.

Charles ; on the sea shore, fl. July, no. 413.

Rubiaceae.

Borreria ericifolia *Hook. f.* in Trans. Linn. Soc. xx. 218 ; Andersson l.c. 77, t. 8, f. 2 ; Robinson l.c. 205, partim ; Stewart l.c. 146, partim, non Hook. f.

Charles ; on hillside, fl. July, no. 416.

This agrees with the type specimen in Hooker's herbarium at Kew. The Galapagos species of *Borreria* are very critical, and have been confused. *Bauer* 137 (Herb. Kew.) cited by Robinson as *B. ericifolia* is *B. divaricata* Hook. f., and *Stewart* 3487 (Herb. Kew.) is *B. parvifolia* Hook. f.

Chiococca alba (*L.*) *Hitchc.* ; Stewart l.c. 145.—*C. racemosa* L. ; Andersson l.c. 78 ; Robinson l.c. 206. *C. trisperma* Hook. f. l.c. 219 ; Andersson l.c. t. 9, f. 2. *Lonicera alba* L.

James ; salt lagoon near coast of James Bay, fl. July, no. 390.

Compositae.

Baccharis sp.

James ; thicket among lava rock on mountain ridge, 120 m., fl. July, no. 393.

The specimen is in fruit ; the flowers are described as mauve in colour. The material is insufficient for description ; it may be conspecific with the " *Baccharis* sp., James ; *Stewart* 714 " (Stewart l.c. 149), which I have not seen. No. 393 is a bush 10 ft. high.

Erigeron lancifolius *Hook. f.* in Trans. Linn. Soc. xx. 208 ; Robinson l.c. 212 ; Stewart l.c. 151.

Albemarle ; Tagus cove, near sea-shore, no. 445 ; Black Bight Bay, no. 446 ; 30 m., no. 452.

These specimens have glandular scabrid leaves. Hooker describes the leaves as puberulous merely, as is the case with the specimen, collected by Darwin, in the Kew Herbarium.

E. tenuifolius *Hook. f.* l.c. 207 ; Robinson l.c. ; Stewart l.c. 152.

Charles ; covering large areas, 300 m., fl. July, no. 430, "Very tall leafy stems from 5-10 ft. high branched at the top ; flowers white with a yellow centre." James ; thicket among lava rock on mountain ridge, 120 m., fl. July, no. 393 bis.

The specimen from James agrees with *Stewart* 739 from the same locality, which has a denser indumentum on leaves and involucre than the type.

Lecocarpus pinnatifidus *Decaisne*, Bot. Voy. Venus, Atlas, t. 14 (1846); Hook. f. l.c. 210; Andersson l.c. 73; Stewart l.c. 154.—*L. foliosus* Decaisne l.c., texte, 20 (1864); Robinson l.c. 213.

Charles; on hill-side, fl. July, no. 414.

Lipochaeta laricifolia (*Hook. f.*) *A. Gray;* Robinson l.c. 214; Stewart l.c.—*Macraea laricifolia* Hook. f. l.c.; Andersson l.c. 72. *Trigonopterum Ponterii* Andersson in Vet.-Akad. Handl. 1855, 184, et in Freg. Eugenies Resa, Bot. t. 6, f. 1.

Charles; on side of crater, 150 m., fl. July, no. 434.

Pectis subsquarrosa (*Hook. f.*) *Schultz Bip.;* Robinson l.c. 215; Stewart l.c. 155.—*Lorentia subsquarrosa* Hook. f. l.c. 206.

Indefatigable; Conway Bay, on shelly beach, fl. July, no. 405.

Previously recorded for Chatham Island only.

P. tenuifolia (*DC.*) *Schultz Bip.*; Robinson l.c.; Stewart l.c.—*Lorentia tenuifolia* DC.; Hook. f. l.c.

Albemarle; fl. Aug., no. 448.

Scalesia affinis *Hook. f.* l.c. 212; Hook. Ic. Pl. t. 2718 (1901); Robinson l.c. 216; Stewart l.c. 156.

Charles; fl. July, no. 422.

I have compared this with the material of the type in the Cambridge Herbarium collected by Darwin on Charles at the end of September, 1835. Darwin's specimens have a slightly coarser indumentum of the leaves and larger capitula with much longer peduncles. The material of no. 422 is poor; the stout branchlets give it an appearance somewhat resembling that of *S. gummifera*. The species has, hitherto, not been represented in the Kew Herbarium.

S. atractyloides *Arn.;* Hook. et Arn. in Hook. Journ. Bot. iii. 312; Robinson l.c.; Stewart l.c., partim.

James; James Bay, 3 miles inland among lava rocks, fl. July, no. 387.

S. gummifera *Hook. f.* in Trans. Linn. Soc. xx. 212; Robinson l.c. 217; Stewart l.c. 157.

Albemarle; on lava, 90 m., fl. Aug., no. 453; Black Bight Bay near lava flow, fl. Aug., no. 447.

Scalesia Stewartii *Riley*, sp. nov.; affinis *S. atractyloidei* Arn., sed foliis brevioribus anguste lanceolatis non lineari-lanceolatis ciliatis utrinque scabris, capitulis multo maioribus, squamis involucri flores longe superantibus differt.

Frutex 1·2–2·4 m. altus. *Ramuli* virgati, robusti, 5 mm. diametro 15 cm. infra apicem. *Folia* anguste lanceolata 4·5–6 cm. longa, 1–1·2 cm. lata, basi in petiolum 3 mm. longum angustata, longe et gradatim acuminata, integra, utrinque scabra, ciliata, costa utrinque et subtus nervis lateralibus etiam

pilis longis indutis. *Capitula* solitaria; pedunculus 9 mm. longus, scaber, pilis longis sparsus. *Squamae involucri* biseriales; exteriores 2·2 cm. longae, e basi 4·5 mm. lata gradatim acuminato-attenuatae, ciliatae, utrinque scabrae; interiores 1 cm. longae, 3 mm. latae. *Paleae* 3-dentatae dentibus iterum dentatis, minute pubescentes.—*S. atractyloides* Stewart in Proc. Calif. Acad. ser. 4, ii. 156, partim, non Arn.

Galapagos: James Island, northeast side on lava beds near the coast and above 700 feet, fl. July, *Stewart* 667 (type in Herb. Kew.).

Stewart (l.c.) referring to this number remarks that "the leaves of the specimens from this locality are more scabrous and less pubescent on the lower surface than are the specimens taken in the vicinity of James Bay. The specimens agree with the rather brief description of this species [*S. atractyloides*], except that the heads are considerably smaller." I take this to mean that the heads of *S. atractyloides* are considerably smaller than those of *Stewart* 667. That this is so is readily seen on comparison of the type specimen of *S. atractyloides* in the Kew Herbarium with the type specimen of *S. Stewartii*. The specimen of *Stewart* 666 in the Kew Herbarium, which he collected at James Bay, and cites as *S. atractyloides*, agrees in all respects with the type of that species.

S. villosa *Stewart* in Proc. Calif. Acad. ser. 4, i. 158, t. 4, ff. 1–3 (1911).

Charles; no. 411.

I have seen no authenticated material of this species, and have identified the above from the description and figures with which it well agrees.

Plumbaginaceae.

Plumbago scandens *L.*; Robinson l.c. 185; Stewart l.c. 121.

Charles; 120–150 m., fl. Aug., no. 426. James; 90–120 m., fl. July, no. 394.

Apocynaceae.

Vallesia glabra (*Cav.*) *Link*; Stewart l.c.—*V. cymbifolia* Ortega; Robinson l.c. *Rauwolfia glabra* Cav. Ic. iii. 50, t. 297.

Indefatigable; Conway Bay, on sea shore, fl. July, no. 410.

V. pubescens *Andersson* in Vet.-Akad. Handl. 1855, 195; Robinson l.c.; Stewart l.c.

Charles; on sea-shore, fl. July, no. 419.

V. pubescens seems hardly more than a variety of *V. glabra*, the only distinguishing character being the indumentum. According to the distribution in the Galapagos given by Stewart, the two species are common to Albemarle, Charles, Hood, and Indefatigable Islands.

Previously represented at Kew by a fruiting specimen collected on Charles Island by Edmonston.

ASCLEPIADACEAE.

Asclepias angustissima *Andersson* in Vet.-Akad. Handl. 1855, 196, et in Freg. Eugenies Resa, Bot. 79 ; Robinson l.c. ; Stewart l.c. 122.

Albemarle ; Tagus cove, fl. Aug., no. 442.

Until now this species has been entirely unrepresented in the Kew Herbarium. I have identified no. 442 from Andersson's description. Field notes referring to this specimen give the height of the plant as about a foot and the colour of the flowers green.

BORRAGINACEAE.

Cordia Hookeriana *Gürke ;* Robinson l.c. 190 ; Stewart l.c. 127, partim.—*C. linearis* Hook. f. in Trans. Linn. Soc. xx. 199, non DC. *Varronia linearis* Andersson in Freg. Eugenies Resa, Bot. 84, t. 11, f. 4.

James ; James Bay, 3 miles inland among lava rocks, fl. July, no. 388.

C. Hookeriana is very closely allied to *C. revoluta* Hook. f. The latter may be distinguished by the broader leaves which are more scabrid, especially on the under surface on the mid-rib. Hooker (l.c.) refers to the obtuse leaves and robust habit of *C. revoluta*, characters which do not seem reliable for distinguishing the two species. It is possible that *C. Hookeriana* and *C. revoluta* are conspecific, but I do not feel justified in uniting them on the material to which I have had access.

Stewart 3175 from James Bay which has been distributed as *C. Hookeriana* is undoubtedly *C. revoluta*, hitherto recorded for Charles and Albemarle Islands only.

C. lutea *Lam. ;* Hook. f. l.c. 198 ; Robinson l.c. ; Stewart l.c. 128.—*C. rotundifolia* Ruiz et Pav. *Varronia flava* Andersson.

Charles ; on the crater, 150–180 m., fl. July, no. 435.

Heliotropium curassavicum *L. ;* Andersson l.c. 86 ; Robinson l.c. 192 ; Stewart l.c.

Charles ; on the sea shore, fl. and fr. Aug., no. 427. Indefatigable ; on the sea shore, fl. and fr. July, no. 409.

As Andersson remarks, the colour of these Galapagos plants is more intensely glaucous than in those from the mainland. In the dried specimens cited above, the colour of that from Charles Island is almost a vivid electric blue, and of the specimen from Indefatigable indigo. Examination of the wide range of material now in the Kew Herbarium shows that the more densely caespitose stems and broader leaves referred to by Andersson as differentiating characters do not hold good.

H. parviflorum *L. ;* Robinson l.c. ; Stewart l.c. 129.

Charles ; growing among volcanic stones everywhere, fl. July, no. 437.

Tournefortia pubescens *Hook. f.* l.c. 198 ; Robinson l.c. 193 ; Stewart l.c. 130.

Charles ; on hillside, 120 m., fl. July, no. 421. At top of a crater, 360 m., no. 431.

I have compared these specimens with the type material in the Cambridge University Herbarium collected by Darwin on Chatham Island. The inflorescences of this material are in a younger state and consequently much more compact, otherwise it agrees. Hitherto the species has not been represented in the Kew Herbarium.

T. pubescens var. **Bauri** *Riley*, var. nov. ; foliis utrinque sparsissime pubescentibus, ramulis petiolisque minus pubescentibus, spicis brevioribus et paucioribus a typo recedit.—*T. pubescens* Robinson in Proc. Amer. Acad. xxxviii. 193, partim, non Hook. f.

Chatham ; *Baur* 206 (in Herb. Kew.).

This specimen was determined at the Gray Herbarium as *T. opaca* Andersson. Robinson, l.c., says that he is " quite unable to separate *T. opaca* Andersson, which appears to be only a glabrate state " from *T. pubescens*. I have not seen any authenticated material of *T. opaca*, but Baur's specimen does not agree with Andersson's description. The leaves are broader in proportion to their length, the petioles are a little over $\frac{1}{4}$ inch long instead of being often an inch long, and the tube of the corolla is double the length of the calyx, whereas Andersson described it as 2–3 times as long. I have compared *Baur* 206 with the type specimen of *T. pubescens* collected by Darwin on Chatham, from which it must certainly be separated as a variety.

On the other hand, there is in the Kew Herbarium a sheet of a *Tournefortia*, collected by Douglas on James Island, which is cited by Hooker (l.c. 198) as *T. psilostachya* H.B.K. This material I have compared carefully with Andersson's description of *T. opaca*, and I consider it to represent that species. It agrees with Andersson's description except that the petioles are about $\frac{3}{4}$ inch long ; the tube of the corolla is generally a little over twice as long as the calyx. I notice an important difference in the number of lateral nerves in the leaf in this species compared with *T. pubescens*. In the former the number of nerves on each side of the mid-rib in the largest leaf is only nine, and in others six or seven. In *T. pubescens* the number varies from ten to fourteen.

Convolvulaceae.

Ipomoea linearifolia *Hook. f.* in Trans. Linn. Soc. xx. 204 ; Andersson in Vet.-Akad. Handl. 1855, 212 ; Robinson l.c. 188 ; Stewart l.c. 124.

Indefatigable ; two miles inland at base of crater, fl. and fr. July, no. 402.

Previously recorded from James Island only, where it was collected by Darwin in 1835 and by no subsequent collectors. This material from Indefatigable bears both flower and fruit, and in these respects supplements the two sheets of the species in the Kew Herbarium.

SOLANACEAE.

Cacabus Miersii (*Hook. f.*) *Wettst.*; Stewart l.c. 137.—*Dictyocalyx Miersii* Hook. f. in Trans. Linn. Soc. xx. 203. *Thinogeton Miersii* Miers ; Robinson l.c. 201.

Albemarle ; Tagus Cove, on rocky ground close to the sea, fl. and fr. Aug., no. 451.

Hooker, l.c., based this species on material collected by Darwin on Charles Island, and by Macrae on Albemarle. The description, however, was evidently drawn up from Macrae's specimen in the Kew Herbarium. I have seen Darwin's specimen, which is in the Cambridge University Herbarium, and the following discrepancies with Hooker's description may be noted:—it is with great difficulty that any glands can be detected in the pubescence even under a high-power lens, the leaves are 3 inches broad instead of 1–2 inches, the petioles are as long as the lamina instead of two to three times longer, and the calyx is over half-an-inch instead of under a third of an inch long. Hooker himself says that *C. Miersii* "appears, judging by Galapagoan specimens, to vary considerably in the size of all its parts." It seems probable that two species were included in the original *Dictyocalyx Miersii*, but examination of a wider range of material is desirable before they can be separated satisfactorily. Macrae's specimen from Albemarle should be regarded as the type on account of its agreement with Hooker's description.

Lycopersicum Cheesmanii *Riley*, sp. nov.; ab *L. esculento* ramulis anfractuosis, indumento dense tomentoso pilis patentibus paucioribus brevioribusque, segmentis foliorum integris vel subintegris, ab *L. peruviano* indumento perglanduloso, pseudostipulis bracteisque absentibus recedit.

Planta 0·3 m. alta, fulvo-tomentosa, dense stipitato-glandulosa. *Ramuli* anfractuosi, teretes, 1·75 mm. diametro 15 cm. infra apicem. *Folia* inaequaliter pinnatisecta, 2·5–4 cm. longa, 1–2 cm. lata, segmentis utrinque 4–5 orbicularibus inaequaliter cordatis rotundatis integris vel leviter sinuatis. maioribus 3–4·5 mm. diametro ; segmentum terminale ovatum vel ovato-lanceolatum, 6–9 mm. longum, 3·5–5 mm. latum, basi obtusum vel subcordatum, apice obtusum integrum vel leviter sinuatum, basi rarius lobatum. *Cymae* plerumque simplices, rarius dichotomo-ramosae, 4–5·5 cm. longae, sub fructu reflexae ; pedicelli circiter 1 cm. longi, supra medium articulati. *Calyx* 4 mm. longus, lobis acutis vel subacutis vix

1 mm. latis marginibus ciliatis. *Corolla* lutea, 1 cm. longa, lobis reflexis subulato-triangulatis 7 mm. longis basi 2·5 mm. latis subacutis extra pubescentibus. *Antherae* 7·5 mm. longae, parte connata 4·5 mm. longa. *Ovarium* globosum, 1·25 mm. diametro, basi truncato ; stylus 9 mm. altus. *Bacca* globosa, 9 mm. diametro, sparse pubescens, calyce accerescenti 6·5 mm. longo amplectente.—*Lycopersicum peruanum* var. *parviflorum* Hook. f. in Trans. Linn. Soc. xx. 202 ; Robinson in Proc. Am. Acad. xxxviii. 199 ; Stewart in Proc. Calif. Acad. ser. 4, i. 139.

Galapagos : Indefatigable ; among lava rock in grassy patches, fl. and fr. July, *Cheesman in Riley* 403 (type in Herb. Kew.). Chatham ; fl. Sept., *Darwin*.

Hooker, l.c., appears to have noticed no difference between Darwin's specimens and specimens from Peru (*L. peruvianum* Mill.), except that the flowers of the latter are larger. The very glandular pubescence and the absence of " stipules " and bracts in Darwin's plant seem to have escaped his notice entirely. The specimen of Darwin's plant in the Hookerian Herbarium, named " *Lycopersicum peruanum* var." which I refer to *L. Cheesmanii* differs from the type of the latter species in the much less anfractuose stem and in the ovate leaf-segments which are mostly sinuate-dentate. It is, however, a very poor specimen. Andersson in Vet.-Akad. Handl. 1855, 216, describes two forms of *L. peruvianum* as occurring in the Galapagos. The first is from Albemarle and has subappressed hairs and sinuate-erose leaf-segments ; the second, from Chatham, has long divaricate hairs and deeply divided leaf-segments. I have not seen Andersson's specimens and cannot refer any material from the Galapagos that I have seen to either of his two forms, or, indeed, to any form of *L. peruvianum* at all. The references by Robinson and Stewart to *L. peruvianum* var. *parviflorum* are merely to Darwin's plant. Robinson, however, remarks that he has " seen no specimens from the Galapagos with the foliaceous bracts said to be characteristic of this species." He states that " a variety of *L. peruvianum* was collected in the Galapagos Islands by Habel." I know nothing about this plant, and Stewart does not refer to it. As to the " *Lycopersicum* sp., *Snodgrass* and *Heller* 526," cited by Robinson and Stewart, I have not seen it, and I doubt whether it can be referred to *L. Cheesmanii* owing to its being " quite destitute of the spreading-hirsute character shown by the other Galapageian specimens at hand " (Robinson l.c. 200).

Scrophulariaceae.

Capraria biflora *L.* ; Andersson in Vet.-Akad. Handl. 1855, 218 ; Sprague in Kew Bull. 1921, 209.—*C. biflora* var. *pilosa* Griseb. in Fl. Brit. W. Ind. 427 ; Robinson l.c. 202 ; Stewart l.c. 141.

Charles ; on a crater, 300 m., fl. and fr. July, no. 436.

Robinson and Stewart refer all the Galapagos material of *C. biflora* to Grisebach's variety *pilosa*. The specimen which

I cite above certainly agrees with the specimens from the Turks Islands and Trinidad named *C. biflora* var. *pilosa* in Grisebach's writing, but examination of the large amount of material in the Kew Herbarium shows that *C. biflora* varies so much in indumentum that I do not consider the more hairy-leaved forms worthy of varietal rank. A specimen in the Kew Herbarium collected by Andersson, presumably on Charles, has the leaves glabrous except on the costa and the margins.

ACANTHACEAE.

Tetramerium hispidum *Nees* in DC. Prodr. xi. 468 (1847); Robinson l.c. 204; Stewart l.c. 142.—*Tetramerium* n. sp. Hook. f. in Trans. Linn. Soc. xx. 195.

James; *Darwin*. 120 m., fl. July, no. 396.

In both these specimens the bracts are less strongly ciliate and less hairy than in other specimens in the Kew Herbarium referred by Nees von Esenbeck to this species.

Ruellia sp.

James; 120 m., fl. July, no. 395.

A low-growing straggling plant with mauve flowers. I am unable to refer this plant to any described species of *Ruellia*, nor have I seen any material with which it is comparable. Unfortunately the specimens are very poor, and insufficient to justify describing a new species in an already confounded genus.

VERBENACEAE.

Avicennia nitida *Jacq.*—*A. tomentosa* Jacq. *A. officinalis* Robinson l.c. 194, et Stewart l.c. 131, non L.

Indefatigable; Conway Bay, fl. July, no. 407. James; fl. July, no. 385.

A. officinalis L. seems to be quite distinct from any species of *Avicennia* found on the shores of the New World. The glabrous but ciliate bracts usually rounded at the apex are characteristic of *A. officinalis*, and the leaves are usually much broader and with fewer nerves than in *A. nitida*, which has tomentose or pubescent bracts, not ciliate and usually acute at the apex.

Clerodendron molle *H. B. K.* Nov. Gen. et. Sp. ii. 244 (1817); Hook. f. in Trans. Linn. Soc. xx. 195; Robinson l.c.; Stewart l.c. 132.—*C.* sp. Hook. f. l.c. 261.

Charles; 120–150 m., fl. Aug., no. 429.

With this I associate specimens from Charles collected by Edmonstone and Markham, from James by Scouler, and from Charles or James by Andersson, from the Cerrito of Guayaquil by Cuming (no. 32), and from Guayaquil by Jameson, all in the Kew Herbarium. Cuming's and Jameson's specimens are named *C. molle*, but I do not feel satisfied with the determination. On comparison with Kunth's description, it is seen that these

plants differ in the leaves being coarsely pubescent above and not glabrous, and having much shorter petioles, usually about two lines long instead of four. The peduncles are not longer than the leaves, and the corolla-tube is only about half an inch long instead of nearly one inch. Moreover, Cuming's specimen is from the Cerrito of Guayaquil, whereas *C. molle* is described as growing in "*locis inundatis prope Guayaquil.*" Jameson's specimen is localized merely as "Guayaquil." That we have here a *Clerodendron* common to the Galapagos and to the coast of Ecuador is evident, but I am not at all certain whether it is *C. molle* H. B. K. I have not seen the type of *C. molle* nor any authenticated material. It is noticeable that Schauer (DC. Prodr. xi. 659) makes no mention of having seen any material of *C. molle.*

Andersson's specimen from Charles or James has larger leaves and more narrowly triangular acuminate calyx-lobes than the rest of the material I have cited, but agrees with it in other respects.

Labiatae.

Salvia occidentalis *Sw.;* Robinson l.c. 197; Stewart l.c. 135.
Charles; fl. July, no. 432, 438.

Amarantaceae.

Telanthera nudicaulis (*Hook. f.*) *Moq.-Tand.* in DC. Prodr. xiii. pars 2, 369; Andersson in Freg. Eugenies Resa, Bot. 62. t. 5, f. 1; Robinson l.c. 139; Stewart l.c. 58.—*Bucholtzia nudicaulis* Hook. f. in Trans. Linn. Soc. xx. 191.
Charles; fl. July, no. 415.

Nyctaginaceae.

Cryptocarpus pyriformis *H. B. K.* Nov. Gen. et Sp. ii. 188, t. 124; Robinson l.c. 142; Stewart l.c. 61.
Charles; on the shore, fl. July, no. 418. Indefatigable, Conway Bay, on the beach, fl. July, no. 406. James; on the coast near salt lagoon, fl. July, no. 389.

The material from Charles Island has much less densely pubescent leaves cuneately narrowed into longer petioles than that from Indefatigable and James.

Piperaceae.

Peperomia obtusilimba *C. DC.* apud Stewart l.c. 49.
Charles; growing in masses on rocks, fl. July, no. 433.

I have seen no authenticated material of this species, and have identified the specimen from the description. The peduncles of no. 433 are slightly longer and the spikes shorter than those of the type, according to the measurements given.

The stems are from 1–2 mm. thick and not "½ mm." thick; it seems possible that the latter measurement may be a misprint.

EUPHORBIACEAE.

Euphorbia amplexicaulis *Hook. f.* in Trans. Linn. Soc. xx. 183; Robinson l.c. 166; Stewart l.c. 90.

Charles; on rocks at the edge of the sea, growing in slight soil in cracks of rock, fl. and fr. Aug., no. 423.

This material is very fine, and shows the whole character of the plant, which, hitherto, has been represented in the Kew Herbarium by small scraps only and without fruit.

PSILOTACEAE.

Psilotum triquetrum *Sw.*; Baker, Handbook Fern-Allies, 30.

James; in fissures of lava rock, no. 392.

So far as I can ascertain, this has never before been recorded from the Galapagos. It is widely distributed throughout the tropics, and occurs on the Pacific coast of South and Central America.

XXVI.—SPECIES OF GREWIA DESCRIBED BY BOJER.

M. L. GREEN.

In 1846 Bojer gave detailed descriptions of six new species of *Grewia* found by him in Madagascar and Tropical East Africa. The paper was published in the Procès-Verbaux de la Société d'Histoire Naturelle de l'Ile Maurice, 1842–1845, pp. 26–30 (1846), and is exceedingly rare. It is not mentioned by Pritzel, and is not represented at Kew, nor apparently in the libraries attached to the Herbaria at Paris, Berlin and the Arnold Arboretum. There are copies, however, in the libraries of the Royal Society and Linnean Society, and at the British Museum (Natural History).

The paper was overlooked during the compilation of the Index Kewensis. Three of the six species were entirely omitted from the Index. In the case of *Grewia stenophylla*, which was the only species cited from Bojer's paper, the reference was apparently taken up at second-hand from J. G. Baker in Journ. Bot., 1882, p. 47. *G. ulmifolia* Boj. was cited from Hort. Maurit. p. 44 (1837), where there is no description, and *G. micrantha* was taken up from Masters in Oliv. Fl. Trop. Afr. i. p. 244 (1868). Bojer's memoir was overlooked by Baillon, who gave a list of forty-three species of *Grewia* known to him from Madagascar,* and more recently by Palacky† and by Burret, who published an enumeration of the African species of *Grewia*.‡

* Bull. Soc. Linn. Par. i. pp. 543–544, 548–552, 557–559 (1886). † Cat. Pl. Madag. fasc. v. p. 31 (1907). ‡ Engl. Bot. Jahrb. xlv. pp. 156–203 (1910).

In view of the rarity of Bojer's paper and the fact that his descriptions were drawn up from living plants and include details unobservable in herbarium material, it seems desirable to reprint the article, thus rendering it accessible to the general botanical public. Notes on the individual species are intercalated within brackets. For these I am indebted to Mr. T. A. Sprague, who has paid special attention to the *Tiliaceae*.

For the convenience of the reader, the more obvious grammatical and orthographical errors in Bojer's descriptions have been corrected, and his punctuation, which is—to say the least—decidedly original, has been modified to bring it more into line with modern practice.

Extracted from Proc.-Verb. Soc. Nat. Hist. Maurice, 1842–45, pp. 26–30 (1846).

M. W. Bojer présente les descriptions suivantes de plusieurs espèces de plantes nouvelles appartenant au genre *Grewia* L., DC. Prod., et provenant de Madagascar.

Grewia ulmifolia (*Boj.*) arborescens, foliis elliptico-oblongis acuminatis, basi retusis emarginatis 3–5-nerviis, serratis lucidis glabris; pedunculis axillaribus solitariis 1–3-floris, bracteis stipulisque caducis, sepalis 1-nerviis intus purpureis, petalis revolutis enerviis calyce brevioribus; fructus 4-lobus, 4-pyrenus; tunica duplex, prim. coriacea, secund. reticulato-fibrosa; nuces 3-loculares, loculis 1-spermis; flores purpurei.

Observavi ad oras orient. Africae aequinoct. praesertim in plagis sinu Bombatoc (Madagas.) in insulis Zanzibar et Pemba; nunc culta in hortis ins. Mauritii.

Arbuscula 10–15-pedalis. *Caulis* erectus, cortice rufescente rugoso vestitus. *Rami* elongati, horizontales vel nutantes, rugoso-ferruginei, juniores geniculati virides. *Folia* deorsum versa, elliptico-oblonga, acuta vel acuminata, basi retusa forte emarginata, margine tantum colorata, inaequaliter serrata, plus minusque basi integra, 4-poll. longa, 2-poll lata, lucida utrinque glabra, nervis 3–5 ex summo petioli gerentibus [orientibus] albidis, venis transversalibus parallelis. *Petioli* crassi, 6 lin. longi, teretes, glabri, stipulis linearibus subfalcatis petiolo longioribus caducis. *Pedunculi* axillares, plerumque solitarii, triflori (1-flor. per abort.), puberuli, petiolo longiores, erecti. *Flores* sat magni, purpurei. *Calycis* sepala lineari-lanceolata, reflexa, intus purpurea, extus viridia, 1-nervia, asperata, 6 lin. longa, lineam lata, bracteis setaceis calyce long. aequantibus caducis. *Petala* calycibus et stam. duplo breviora, apice revoluta bifida vel integra, margine involuta, basi concava unguiculata esquamosa. *Stamina* circiter 80, erecta, toro crasso piloso inserta, filamentis tenuibus purpureis. *Antherae* globosae, luteae, 2-loculares. *Stylus* stam. paulo longior. *Stigma* capitatum, viride. *Ovarium* hemisphaericum, hispidum, 4-loculare. *Fructus* drupaceus, exsuccus, 4-lobus (1-lob. per abort.),

4-pyrenus ; integumentum duplex, exter. coriaceum, obscure luteum, asperum, inter reticulato-fibrosum, albidum ; nuces in pulpa farinosa nidulantes, cuneatae, dorso convexo parum sulcato, 1–3-loculares, loculis 1-spermis.

Obs.—M. Bojer avait déjà communiqué à la Société, en 1829, la description et un dessin colorié du *G. ulmifolia* Boj. Il avait en même temps fait connaître plusieurs autres plantes nouvelles également recueillies dans ses voyages à Madagascar, et parmi lesquelles se trouvait entre autres celle dont il avait formé son genre *Siphomeris*, et que M. A. Richard, à peu prés à la même époque décrivait de son côté dans sa monographie des Rubiacées sous le nom de *Lecontea*. Voy. *Memoire sur la famille des Rubiacées*. Ach.-Richard. Paris 1830, et DC. Prod. vol. iv. p. 470.

[p. 27] M. Bojer n'ayant pu insérer dans le Rapport publié par la Société en 1830 son travail tout entier, l'a addressé dans le cours de cette même année 1830, à la Société Médico-Botanique de Londres ; mais depuis cette époque il n'en a pas entendu parler ; aucun ouvrage parvenu à la connaissance de M. Bojer du moins, n'en a fait mention. Il est donc à supposer que les plantes dont M. Bojer fait connaître aujourd'hui les caractères, constituent des espèces tout à fait nouvelles pour la science.

Les habitans des îles Zanzibar, Pemba et autres îles où croît le *G. ulmifolia* Boj. emploient ses jeunes branches comme dentifrices. Il n'est pas rare de rencontrer dans les rues, dit M. Bojer, des groupes nombreux d'Arabes, tenant à la main des branches de cette plante dont ils se servent pour se frotter les dents, que l'usage immodéré du bétel, de la chaux et de la noix d'areca a colorées en rouge.

Si les Arabes emploient les jeunes branches du *G. ulmifolia* Boj. pour se blanchir les dents, les habitans de Madagascar au contraire se servent, pour les noircir, de celles du *Lingun*, *Siphomeris Lingun* Boj., *Lecontea Bojeriana* Ach.-Rich. M. Bojer dit avoir vu les habitans des provinces ou le *Lingun* est rare, se rendre en foule dans les marchés voisins ou cette plante est mise en vente pour en acheter les jeunes branches dont ils se frottent les dents qui deviennent alors et en peu de temps d'un noir de jais, caractère qui constitue, selon ces habitans, un genre de beauté dont ils font le plus grand cas.

[A coloured drawing inscribed in Bojer's handwriting "*Grewia ulmifolia* Boj. Mrs. Chs. Telfair delt." is preserved in the Kew Collection. Bojer in 1829 sent Dr. W. J. Hooker "a box containing drawings of some rare plants which I think will be interesting to you,"* and the drawing of *Grewia ulmifolia* was probably among these. There is also a type specimen in the Hookerian Herbarium, communicated by Bojer and labelled by him *Grewia ulmifolia* Boj. Both drawing and specimen represent a form with broad, distinctly cordate leaves. *G. ulmifolia* Boj. is now treated—apparently correctly—as a synonym of *G. glandu-*

* Hook. Corresp. lii. 3.

losa Vahl, which judging from Vahl's description of the leaves as ovate-lanceolate, was based on a narrower leaved and non-cordate form, such as was subsequently figured by Jussieu.*

Vahl described *G. glandulosa* as a native of Isle of France [Mauritius], and this erroneous statement was repeated by Jussieu, De Candolle, Masters, K. Schumann and Engler (vide loc. infra cit.) As stated by Bojer, the species is a native of Madagascar and Tropical East Africa, and is merely cultivated in Mauritius. According to Baker,† no species of *Grewia* is indigenous in Mauritius.

Bojer's description is by far the best and most complete account of the species, containing many details not mentioned by other authors. The principal references to *G. glandulosa* and *G. ulmifolia* Boj. are given below.

Grewia glandulosa *Vahl* Symb. i. 34 (1790); Willd. Sp. Pl. ii. 1166; Juss. in Ann. Mus. Hist. Nat. Par. iv. 91, t. 48, f. 1 (1804); DC. Prodr. i. 510; Mast. in Oliv. Fl. Trop. Afr. i. 246; K. Schum. in Engl. Pflanzenw. Ost-Afr., Theil C, 263; Burret in Engl. Bot. Jahrb. xlv. 196; Engl. Pflanzenw. Afr. iii. Heft 2, 363. *G. ulmifolia* Boj. Hort. Maurit. 44 (1837), nomen; Boj. in Proc.-Verb. Soc. Nat. Hist. Maur. 1842–45, 26 (1846), descr.; non Roxb. (1832).—T. A. S.]

G. stenophylla (*Boj.*) fruticosa, ramulis calycis et folia omnino pilis rufis stellatis dense obductis, foliis lineari-lanceolatis coriaceis breviter petiolatis acutis serrulatis, basi obtusis 3-nerviis, stipulis petiolo longioribus caducis, pedunculis brevibus oppositifoliis 1–3-floris, sepalis 1-nerviis bracteis setaceis longioribus. Calyx intus, petalis et staminibus purpureis. Fructus ignotus.

Crescit in convallis elatis montibus provinc. Emirnae interior. ins. Madagascar.

Frutex confertus, 5–6-pedalis, ramis elongatis adultis fusco-purpureis glaberrimis, novellis secus ramos approximatis horizontalibus tenellis ferrugineis stellato-pubescentibus. *Folia* conferta, erecta, lineari-lanceolata, acuta, inaequaliter serrulata, basi obtusa, nervis 3 subtus prominulis, supra obscure, subtus luteo-viridia, utrinque stellato-pubescentia, 2 poll. longa, 4 lin. vix lata, interdum minora. *Petioli* 2 lin. longi, cum ramulis stellato-pubescentes, stipulis setaceis petiolo longioribus caducis. *Pedunculi* oppositifolii, petiolo long. aequantes 1–3-flori, bracteis setaceis caducis, stellato-puberuli. *Flores* purpurei, [iis] *G. occidentalis* crassiores et majores. *Calycis* sepala lanceolata, acuta, reflexa, 7 lin. longa, lineam vix lata, 1-nervia, intus basi cum petalis spacellatis [? sphacelatis] pilosa, iis paulo longiora. *Stamina* circiter 60, erectiuscula, purpurea. *Antherae* globosae, luteae, 2-loculares. *Stylus* filam. crassior et longior. *Stigma* acutum. *Ovarium* hemisphaericum, pilosum, 4-loculare. *Fructus* desideratur.

* Ann. Mus. Par. iv. t. 48, fig. 1 (1804).
† Fl. Mauritius & Seychelles, 31 (1877).

[p. 28] *Obs.*—Cette espèce de *Grewia* paraît avoir quelques rapports avec le *G. salvifolia* Roth, dont elle diffère par ses feuilles qui sont plus étroites et d'une couleur verdâtre en dessous ; le *G. stenophylla* Boj. d'ailleurs, se distingue particulièrement de toutes les autres espèces décrites, par ses grandes fleurs presque sessiles et d'une belle couleur pourpre.

[*G. stenophylla* is represented in the Kew Herbarium by a specimen labelled "*Grewia stenophylla* Boj. In Ins. Madagascar," received from Bouton in 1857, and by another received from Bojer at an earlier date under the manuscript name *Grewia salviaefolia* Boj. These may be regarded as syntypes. There are also specimens collected in Madagascar by Lyall, no. 159, and Baron, no. B. 460. All these specimens have the sepals considerably broader than described by Bojer, and the stigmas broad and flattened, not acute. In other respects they agree fairly well with Bojer's description. It is difficult to account for these discrepancies.

G. stenophylla was mentioned incidentally by Baker in Journ. Bot. 1882, 47, in describing a new species, *G. grandiflora*, from Madagascar. This is the only reference which has been traced. —T. A. S.]

G. micrantha (*Boj.*) fructicosa, fasciculato-pilosa, foliis breviter petiolatis ovalibus acutis serrulatis, basi inaequalibus 3-nerviis, subtus incanis, stipulis oblongis petiolo longioribus, pedunculis 3 axillaribus tenellis petiolo multo longioribus 3-floris, bracteis spacellatis [? sphacelatis], sepalis 1-nerviis, floribus parvis, petalis brevissimis, antheris pilosis.

Hab. in campis aridis montibus nudis, prov. Betsilou, interior. ins. Madagascar.

Frutex altitudine varians, ramosus. *Caulis* ramique inferne glabri, ramulis floriferis gracilibus elongatis fasciculato-pilosis. *Folia* elliptico-ovalia, acuta, serrulata, basi unilaterali oblique inaequalia, 3-nervia, nervis venisque subtus crassioribus utrinque fasciculato-pilosis, interstitiis venarum subtus pube brevissima stellata incanis, supra viridia, 15 lin. longa, 10 lin. lata. *Petioli* lineam vix longi, stipulis oblongis acutis petiolo-longioribus deciduis. *Pedunculi* 3 vel 4, axillares, tenelli, 8 lin. longi, apice triflori, bracteis spacellatis [? sphacelatis] flor. superantibus, extus cum calycibus densius pilosis deciduis. *Flores* parvi, fuscolutei. *Calycis* sepala ovalia, acuta, reflexa, 1-nervia, 2 lin. longa, intus fusca glaberrima. *Petala* lineam vix longa apice, retusa vel bifida. *Stamina* 30–40, erecta, obscure lutea, petalis duplo longiora. *Antherae* globosae, parum pilosae. *Stigma* 5-lobum. *Ovarium* hispidum, toro brevi superpositum, 5-loculare. *Fructus ?*

Obs.—M. Bojer fait observer qu'en raison des charactères ci-dessus tracés le *G. micrantha* vient naturellement se placer dans la première section du genre tel qu'il est établi dans le Prodromus de M. De Candolle, v. I. p. 508. C'est à dire parmi les *Grewia* dont la corolle est nulle ou rudimentaire seulement. Sept espèces

de *Grewia* de cette section sont décrites dans l'ouvrage cité ; le *G. micrantha* ne ressemble à aucune d'elles. La forme oblique de ses feuilles, les fleurs très-petites et très-nombreuses, en raison du nombre des pédoncles triflores, son stigmate à 5 divisions étoilées, le font également distinguer de toutes les autres espèces décrites.

[Represented in the Kew Herbarium by a specimen received from Bouton in 1857, labelled "*Grewia micrantha* (Boj.) ex insula Madagascar." This is probably a syntype. Masters (loc. infra cit.) identified a specimen collected by Kirk at Tette on the Zambesi with *G. micrantha* Boj., which he believed to be a manuscript name. As Bojer's specimen is in flower, and Kirk's is in fruit, a satisfactory comparison is not possible, but there seems to be no reason to doubt that the two are conspecific. The principal references to *G. micrantha* are as follows :

Grewia micrantha *Boj.* in Proc.-Verb. Soc. Nat. Hist. Maur. 1842–45, 28 (1846) ; Mast. in Oliv. Fl. Trop. Afr. i. 244 (1868) ; K. Schum. in Engl. Pflanzenw. Ost-Afr., Theil C, 263 ; Burret in Engl. Bot. Jahrb. xlv. 181 ; Engl. Pflanzenw. Afr. iii. Heft 2, 359. *G. gonioclinia* K. Schum. in Engl. Bot. Jahrb. xv. 119 (1892), fide Burret, l.c. *G. hypoglauca* K. Schum. in Engl. Pflanzenw. Ost-Afr., Theil C, 263 (1895), fide Burret, l.c.

It should be mentioned that Burret's "species" are very comprehensive, and that *G. gonioclinia* and *G. hypoglauca* are here cited as synonyms of *G. micrantha* entirely on his authority. I have not seen authenticated specimens of either.—T. A. S.]

G. rhomboides (*Boj.*) fructosa, erecta, foliis ovato-lanceolatis acutis rigidis subrhombiformibus glanduloso-denticulatis, subtus luteo-viridibus, 3-nerviis, utrinque puberulis, stipulis setaceis caducis, pedunculis axillaribus solitariis vel geminis 3-floris, ovariis appresse pilosis toro colorato longioribus ; fructus cuneatus, subpyriformis, 4-lobus, per abortu 1-lobus gibbosus, hispidus.

Hab. in vallibus locis sylvaticis provinciae Emirnae int. ins. Madagascar.

Frutex 5-pedalis et altior. *Caulis* ramosus, laevis. *Ramis* subpatentibus inferne coloratis glabris, caeteris partibus omnino pube stellata brevissima obductis, ramulis floriferis elongatis gracilibus pulchre arcuatis densius foliatis, apice [p. 29] ferrugineis et magis pilosis. *Folia* ovato-lanceolata, acuta vel acuminata, rigidula, basi obtusiuscula, interdum forte rhombiformia, glanduloso-denticulata, 3-nervia, nervis venisque subtus crassioribus, in axillis nervorum barbulata, supra obscure, subtus luteo-viridia, 15 lin. longa, 8 lin. lata. *Petioli* 3 lin. longi, stipulis setaceis subscariosis brevioribus deciduis. *Pedunculi* axillares, solitarii rarius gemini, erecti, petiolo long. aequales, 3-flori, pedicellis defloratis breviores, bracteis linearibus caducis. *Flores*

obscure lutei. *Calycis* sepala lanceolata, acuta, 3 lin. longa, reflexa, 1-nervia, intus colorata glaberrima. *Petala* oblonga, bifida, calyce breviora, basi unguiculo piloso donata. *Stamina* 45–50, patentia, petalis longiora. *Antherae* globosae, medifixae, croceae, 2-loculares. *Stylus* filiformis, mox deciduus. *Ovarium* elongato-cylindraceum, appresse pilosum, toro crasso colorato longiusculum. *Fructus* exsuccus, cuneatus aut pyriformis, obtuse 4-lobus, 4-pyrenus, abortu 1-lobus, deinde globosus aut gibboso-reniformis, verruculosus, pilosus, 1-pyrenus.

Obs.—C'est encore, dit M. Bojer, une belle espèce de *Grewia* croissant dans la province d'Emirne, et qui, par ses pétales oblongs, ses sépales à une seule nervure médiane et ses feuilles trinervées, vient se placer dans la troisième section du genre tel qu'il est divisé dans le Prodromus de De Candolle. L'espèce dont la description précède est surtout remarquable par son fruit assez gros, pyriforme et à quatre loges, divisé à son sommet en quatre lobes obtus, dont trois avortent assez souvent ; le fruit devient alors globuleux, ou bien les lobes avortés se projettent au milieu du fruit en une excroissance dure, et lui donnent une forme voûtée ou réniforme.

[*G. rhomboides* Boj. is apparently unrepresented in the Kew Herbarium. The leaves seem to approach those of *G. occidentalis* in size and general outline, but are described as acute or acuminate. Palacky, Cat. Pl. Madag. fasc. v. p. 32 (1907) enumerates a "*Grewia rhomboidea* DC.", which has not been traced.—T. A. S.]

G. capitellata (*Boj.*) arborescens, foliis ovatis acuminatis breve petiolatis crenato-dentatis, 3-nerviis, ad basin utrinque dentibus 3, majoribus glanduliferis, juvenibus utrinque stellato-pilosis, veteris rigidis glabris, pedunculis oppositifoliis pollicaribus apice floribus pseudo-umbellatis capitellatis, sepalis 1-nerviis, petalis oblongis subemarginatis ; stigma 4-lobum ; fructus ?

Hab. in rupibus aridis ins. Mombase orae orient. Africae aequinoct.

Arbuscula orgyalis et altior. *Caulis* parce ramosus, laevis. *Ramis* patentibus inferne parum foliatis teretibus fusco-purpureis glabris, ramulis divaricatis gracilibus apicibus pube brevi floccosa obsitis, demum denudatis glabris. *Folia* remota, breviter petiolata, ovalia, acuminata vel acuta, duplicato crenato-dentata, ad basin leviter attenuata utrinque dentibus 3 majoribus recurvis glanduliferis, 3-nervia, minus transverse venosa, reticulata, utrinque floccoso-pubescentia, concoloria, 3 poll. longa, 2 poll. lata, vetera majora rigidiora glabra. *Petioli* lineam vix longi, stipulis caducis brevioribus. *Pedunculi* oppositifolii, solitarii aut bini, inter distantiae fol. [*i.e.* internodiis] longitudine aequales, erecti pubescentes, ad apicem floribus parvis breviter pedicellatis in capitulum aggregatis, bracteis parvis setaceis pedicellis aequantibus deciduis. *Calycis* sepala ovato-oblonga, acuta, enervia ?, extus cum pedicellis densius appresse pilosa. *Cor.* petala oblonga, emarginata, sepalis breviora. *Stamina* numerosa, subpatentia.

Antherae globosae, citrinae, 2-loculares. *Stylus* longitudine staminorum. *Stigma* 4-lobum. *Ovarium* globosum, hispidum, 4-ovulatum. *Fructus ?*

Obs.—Le *G. capitellata* Boj. se distingue des autres espèces du même genre par les trois dents qu'il porte sur les bords et à la base de la feuille, et qui, plus grandes que les autres, sont [p. 30] munies chacune d'une petite glande ; la longueur des pédoncules est égale à la distance qui se trouve entre les feuilles ; ces pédoncules supportent des fleurs nombreuses, assez insignifiantes, en ombelles serrées et formant un capitule.

[*G. capitellata* is represented at Kew by two sheets, one labelled "*Grewia* sp. Hab. in Africae orientalis et in ins. Mombas." without indication of collector (doubtless Bojer), the other, which was received from Bouton in 1857, labelled "*Grewia* sp. In montibus prov. Emirna, Madagascar." The former may be regarded as a syntype. The latter can hardly be regarded as such, since Bojer did not mention the occurrence of *G. capitellata* in Madagascar, and the specimen was therefore presumably collected at a later date.—T. A. S.]

G. comorensis (*Boj.*) arborescens, ramis elongatis albo-punctatis, ramulis axillaribus apice pedunculis alternis umbellatis multifloris, foliis elongato-ovatis acuminatis vel acutis dentato-crenatis, basi integris 3-nerviis, rubro-marginatis puberulis scabris, bracteis bracteolisque linearibus deciduis, sepalis 1-nerviis extus fasciculato-pilosis, petalis oblongis acutis basi pilosis, toro forte 5-gono ; fructus ?

Hab. in montibus sylvigeris ins. Anjouan (seu Johanna) Archip. comorensis.

Arbuscula 8–10 pedalis. *Caulis* proprius parum elatus, cortice bruneo vestitus. *Rami* elongati, horizontales vel arcuati, inf. bruneo-cinerei, parce foliati, juvenes ferrugineo-lutei, albo-punctati, lucidi, glaberrimi, ramulis axillaribus aut extra axill. ortis gracilibus 2–3 poll. longis rectis foliatis floriferis. *Folia* reflexa, elongato-ovalia vel ovata, acuminata vel acuta, interdum obovata, 4–5 poll. longa (incl. petiolo 6 lin.), inaequaliter dentato-crenata, basi subintegra, margine rubro-colorata, 3-nervia, nervis subtus prominulis cum venis transversis parallelis quandoque rubro-coloratis, supra plana, utrinque puberula, scabra (in sicco) pellucido-punctata. *Stipulae* minimae, setaceae, deciduae. *Pedunculi* ad apicem ramulorum orti, alterni, pollicem longi, erecti, pilosi, bracteati, pedicellis circiter 10 umbellatis suffulti, pedicellis pedunculo duplo brevioribus pilosis, bracteolis linearibus pedicello brevioribus deciduis. *Sepala* 3 lin. longa, $\frac{1}{2}$ lin. lata, extus fasciculato-pilosa, intus fusco-rubra, 1-nervia. *Petala* oblonga, acuta, unguiculo piloso, sepalis parum breviora, reflexa, obscure lutea. *Stamina* 45–50, filamentis subpatentibus petalis vix longioribus luteis. *Antherae* ovales, biloculares, citrinae. *Stigma* 4-lobum, stam. vix superans. *Ovarium* pilosum, 4-ovulatum, toro elongato rubro colorato forte 5-gono suffultum. *Fructus ?*

Obs.—Le *Grewia* des Iles Comores paraît avoir quelques rapports avec le *Grewia umbellata* de Roxburgh, quant à la disposition des pédoncules alternes, situés au sommet des petits rameaux ; mais la plante décrite par Roxburgh a les pédoncules triflores, tandis que ceux du Grewia des Iles Comores supportent plusieurs fleurs qui sont disposées en ombelles.

[*G. comorensis* Boj. is represented in the Kew Herbarium by a single sheet, which formed part of the herbarium of Mr. Justice Blackburn presented by Admiral Bowles in 1863. It is labelled—apparently in Bojer's handwriting—"*Grewia Juanensis* Boj. In sylvis insulae Juannae. Flores obscure lutei umbellati." A second, and apparently different, *Grewia comorensis* was described by Baillon in Bull. Soc. Linn. Par. i. p. 558 (1886).—T. A. S.]

XXVII.—MISCELLANEOUS NOTES.

Mr. A. D. Ingrams has been appointed by the Secretary of State for the Colonies, Agricultural Officer, Zanzibar.

The Watermark Disease of the Cricket-bat Willow.*—An article in the *Kew Bulletin* for 1907, p. 311, dealt with the identity of the forms of *Salix* whose timbers are most prized by cricket-bat makers. In a later note (*Kew Bull.* 1912, p. 205) some evidence was adduced showing that the peculiar properties of the best Cricket-bat Willow (*Salix alba* var. *caerulea* or *Salix caerulea*) are inherent, and not dependent on the climatic conditions under which it is grown.

In 1921 a disease of the Cricket-bat Willow, manifested by a dying back of the crown in late spring, became very prevalent in the valley of the river Chelmer. This has been investigated by Mr. W. R. Day, of the Imperial Forestry Institute, Oxford. *Salix alba* and *S. caerulea* are affected, while *S. fragilis*, which is of comparatively little value, appears to be immune. The disease seriously depreciates the value of the timber even in the first year, and in two or three years the trees may become a total loss.

The external features are mainly a withering and dying back of the new shoots in May, soon after growth has commenced. The leaves become brown and may remain on for some time. At the same time adventitious shoots may develop, and there may be exudations of bacteria, especially through wounds made by small hymenopterous insects. These symptoms usually occur on one or more branches, but not over the whole crown.

The feature by which the disease may be distinguished from all others is to be seen on cutting through one of the dying branches. A dark mark, known in Essex as the "watermark," occurs in the wood of the still living parts of the tree. After death this mark

* By W. R. Day, Oxford Forestry Memoirs No. 3, Clarendon Press, Oxford, 1924. Price 3s. 6d.

gradually disappears, leaving only a faint grey stain. The mark has been found to be due to bacteria, which inhabit the wood-vessels and cause the disease. It extends through the dying branches back into the main stem of the tree, and usually down to the root.

The bacterium was isolated and pathogenetically tested by inoculation experiments. In the case of cuttings a wilting of the leaves was produced, but no " watermark," and it was not possible to re-isolate the organism. One inoculation on a branch of a pollard willow, however, produced a typical " watermark," from which the bacterium was recovered. The organism, called *Bacterium Salicis*, was found to penetrate only through wounds.

Later the dying twigs become infected with the fungus *Cytospora chrysosperma*. Experiments were made to determine the relationships of this fungus to the disease and to dying back of the twigs in general. In the case of watermark disease, the fungus is only secondary to the true pathogen. Further, in cases of die-back where *Cytospora* appears to be acting alone, it is shown that the fungus only attacks living tissues when they are in a weak condition and predisposed to disease. It is doubtful whether it can successfully attack any vigorously healthy plant, but should a tree become diseased it is liable to be attacked by *Cytospora*, and death then probably occurs sooner than would otherwise have been the case.

From a study of the method of cultivation of *Salix caerulea* as practised in the Chelmer Valley, the author recommends planting the tree in well-drained localities, with a moist but not too wet subsoil. Generally speaking it is advisable to avoid wet marshy habitats and peaty, clayey, or other impervious soils. The usual sanitary methods of felling and burning diseased trees and choosing healthy sets are to be followed, and it is recommended that the trees should be planted at greater distances than those usually adopted. E. M. W.

Rock Gardening.*—This book is written expressly for the amateur, with brief instructions as to the construction and planting of a rock garden. One chapter is devoted to the construction of a rock garden, which includes the selection of a site; the materials for use; the rock border; the moraine; and wall gardens. Cultivation and soils are dealt with in another chapter, while the remainder of the book is devoted to a selection of the best and most easily grown plants for the beginner.

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* Rock Gardening, by W. Irving. Country Life, Ltd., 20, Tavistock St., London, W.C. 2, pp. 59, ill. 11. Price 2s. 6d.

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